H. P. Williamson

FIRST ANNUAL REPORT SAN FRANCISCO OAKLAND BAY BRIDGE

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FIRST ANNUAL PROGRESS REPORT SAN FRANCISCO OAKLAND BAY BRIDGE

JULY 1, 1934

This copy of the First Annual Report of the progress of construction as of July 1, 1934, of the San Francisco-Oakland Bay Bridge, which has been published to provide the authorities having interest therein with a complete record thereof, is issued to

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Governor Frank F. Merriam
Chairman California Toll Bridge Authority

THE SAN FRANCISCO-OAKLAND BAY BRIDGE

Designed and Constructed by the **DEPARTMENT OF PUBLIC WORKS** *of the* **STATE OF CALIFORNIA** *for the* **CALIFORNIA TOLL BRIDGE AUTHORITY**

CALIFORNIA TOLL BRIDGE AUTHORITY: Frank F. Merriam, *Governor;* George J. Hatfield, *Lieutenant Governor;* Earl Lee Kelly, *Director, Department of Public Works;* Arlin E. Stockburger, *Director, Department of Finance;* Harry A. Hopkins, *Chairman, Highway Commission.*

SAN FRANCISCO-OAKLAND BAY BRIDGE DIVISION *of the* **DEPARTMENT OF PUBLIC WORKS:** Earl Lee Kelly, *Director;* C. H. Purcell, *Chief Engineer;* Chas. E. Andrew, *Bridge Engineer;* Glenn B. Woodruff, *Engineer of Design.*

FINANCIAL ADVISORY COMMITTEE: Harrison S. Robinson, *President;* Leland W. Cutler, *Vice President;* George T. Cameron, *Chairman, Executive Committee;* C. H. Purcell, *Secretary;* W. G. Swanson, *Assistant Secretary;* Joseph Carlston,* Charles O. Conrad, W. W. Crocker, E. B. DeGolia, R. M. Fitzgerald,* Herbert Fleishhacker, A. P. Giannini, R. H. Glassley, E. Clarence Holmes, Joseph R. Knowland, Frank C. MacDonald, P. H. McCarthy,* J. H. Quinn, John P. Symes, George Tourney.*

*Deceased

BOARD OF CONSULTING ENGINEERS: Ralph Modjeski, *Chairman;* Moran and Proctor, Leon S. Moisseiff, Charles Derleth, Jr., H. J. Brunnier.

BOARD OF CONSULTING ARCHITECTS: Arthur Brown, Jr., John J. Donovan, Timothy L. Pflueger.

CONSULTING GEOLOGIST: A. C. Lawson.

ATTORNEYS: Heller, Ehrman, White & McAuliffe.

Artist's conception of Tower W-3 with San Francisco skyline in the background

Preface

The end of the first year in the construction of the San Francisco-Oakland Bay Bridge has given the people of California visual evidence that the project, which has dwelt in the minds of the people around San Francisco Bay for three-quarters of a century, but which many times had been declared by authorities to be an impossible dream, is now far advanced toward completion.

Bridges do not build themselves, and before the labor in concrete and steel, there was the labor in the minds of men; and we, now building this bridge, would be remiss indeed if we did not set forth in the record of caissons sunk and towers raised an acknowledgment of the distinguished public service performed at the birth of this project, and in its subsequent developments, by citizens, public officers and civic organizations.

To those who have contributed their efforts toward building this project, we offer the gratitude of the State of California.

Frank F. Merriam

FRANK F. MERRIAM
Governor

In Memoriam

The California Toll Bridge Authority passed the following resolution:

Whereas, the late James Rolph Jr., contributed immeasurably of his energies and spirit, both as Mayor of San Francisco and as Governor of California, to the public movement which produced the San Francisco-Oakland Bay Bridge; and

Whereas, the San Francisco-Oakland Bay Bridge is to be a monument of such gigantic proportion as to bring world-wide renown to San Francisco, Oakland, and their environs; and

Whereas, although the late James Rolph, Jr., loved all California, yet San Francisco was his birthplace, his home, and nearest to his heart of all the cities of our great State; therefore, be it

Resolved, That within the limitations of the powers vested in the California Toll Bridge Authority, the San Francisco-Oakland Bay Bridge be dedicated as a lasting memorial to James Rolph, Jr.

To His Excellency, **FRANK F. MERRIAM,** *Governor of California, and Members of the California Toll Bridge Authority*

GENTLEMEN:

There is transmitted herewith the First Annual Progress Report of Chief Engineer C. H. Purcell on the construction of the San Francisco-Oakland Bay Bridge.

This First Annual Report covers the period between April 28, 1933, and July 1, 1934.

The date April 28, 1933, is the one on which, as Director of Public Works of the State of California, I awarded contracts to low bidders on each of the six major units of the San Francisco-Oakland Bay Bridge construction, viz: Contracts Nos. 2, 3, 4, 5, 6 and 7, embracing the major substructure, entire superstructure, San Francisco cable anchorage, and Yerba Buena Island tunnel and cable anchorage.

The date July 1, 1934, is the end of the fiscal year immediately following the end of the first year in the construction of the bridge.

Subsequent reports will be made annually covering twelve-month periods ending on July 1 of each succeeding year.

Respectfully submitted

Earl Lee Kelly

EARL LEE KELLY
Director of Public Works

Honorable EARL LEE KELLY
Director of Public Works
of the State of California

SIR:

Submitted herewith is the First Annual Progress Report on the construction of the San Francisco-Oakland Bay Bridge covering the period between April 28, 1933, and July 1, 1934.

Preliminary work on the project was started in 1929. These efforts extended through 1930 and 1931, and constituted a very important step in the development of the project.

The work accomplished prior to July, 1930, is fully set forth in the Hoover-Young Report, which was filed with the Department of Public Works on July 19, 1930. The Hoover-Young Commission reported to Governor Young and the President of the United States on August 6, 1930.

During the period from July, 1930, to July, 1931, further developments were made in the semifinal designs and foundation surveys.

In August, 1931, C. H. Purcell was appointed Chief Engineer. A design organization was formed with offices at 500 Sansome Street, San Francisco, to proceed with the final design and estimates. A consulting board was also appointed.

During the period between July, 1931, and August 1, 1932, a final report on the design and cost estimate, as well as traffic and income, was completed and presented to the California Toll Bridge Authority. In the Fall of 1932, this report, together with additional data, was presented to the Reconstruction Finance Corporation, with a request for complete financing through that body.

Following a complete investigation by the Reconstruction Finance Corporation of all engineering data presented, as well as traffic and income estimates furnished by the engineers of the Department of Public Works, the project was approved by the Reconstruction Finance Corporation.

An agreement, under which the Reconstruction Finance Corporation agreed to buy bonds in an amount not to exceed $61,400,000 for purposes of constructing the bridge, was formally entered into between the Reconstruction Finance Corporation and the California Toll Bridge Authority on December 15, 1932.

Bids for the first contracts of the work were awarded on April 28, 1933.

You are referred to the Hoover-Young Report and the Report to the California Toll Bridge Authority of August, 1932, for progress prior to this report.

Respectfully submitted

C. H. Purcell

C. H. PURCELL
Chief Engineer

Annual Progress Report No. 1

CHAPTER No. I

Section 1

Legislation

Act providing for Investigation of Toll Bridges in California—California Legislature.

Reference: Chapter 636, Statutes of 1927.

General Toll Bridge Laws.

Reference: Senate Bill No. 700, Chapter 763, Statutes of 1929, and Chapter 762, Statutes of 1929, amended by Chapter 399, Statutes of 1931; Chapter 405, Statutes of 1931; and Chapter 400, Statutes of 1931.

Senate Joint Resolution No. 7, petitioning Congress to permit construction of bridge and to grant right of way over Yerba Buena Island as recorded in Statutes of 1931, Chapter 17.

Constitutionality

Decision California Supreme Court on constitutionality of Toll Bridge legislation, Vol. 81.

California Decisions 615, Act of Congress granting consent to State of California to construct, maintain and operate a bridge across bay of San Francisco from Rincon Hill District in San Francisco via Yerba Buena Island to Oakland.

Passed and approved February 20, 1931, Public Bill No. 695—71st Congress (S5825).

Joint Permit by Departments of War, Navy and Commerce to construct bridge and cross Yerba Buena Island granted May 25, 1932.

Act of Congress creating Reconstruction Finance Corporation, and providing for loans by purchase of bonds, to finance self-liquidating projects.

Section 2

Financing, Preliminary and Final Design, and Construction

Under Chapter 763, Statutes of 1929, $50,000 were appropriated to be used by the California Toll Bridge Authority for preliminary investigation. This fund was augmented by an appropriation by San Francisco for $40,000 and by the Port of Oakland for $4,000.

Chapter 400, Statutes of 1931, appropriated a sum of $650,000 for final design of the bridge, this sum to be repaid from subsequent bond sale. It was under this appropriation that an office was opened in San Francisco, a design force

organized and final design developed, together with plans and specifications for the advertising and award of approximately $36,000,000 in contracts. The first of these contracts was advertised in January, 1933, and bids opened on February 28, 1933.

The original conception of financing the project was to sell bonds of the Toll Bridge Authority to private financial interests. However, the financial depression which started in 1930 with the consequential drop in the bond market rendered such a procedure impossible.

The extending of power of the Reconstruction Finance Corporation by Congress, Act of 1932, as requested of Congress by the California Toll Bridge Authority, to loan funds to self-liquidating projects by purchase of bonds offered a fortunate solution to the financing problem.

In August, 1932, a complete report on this project, together with traffic estimates, plans and specifications, was presented to the Reconstruction Finance Corporation and application was made for a loan covering the entire project. After a very thorough and complete investigation of the engineering features of the project and its legal and financial aspects, the project was declared by the Reconstruction Finance Corporation to have complied with all requirements of a self-liquidating project. As a result, an agreement was entered into between the Reconstruction Finance Corporation and the California Toll Bridge Authority whereby the Reconstruction Finance Corporation agreed to buy California Toll Bridge Authority bonds to the amount of $61,400,000 to finance the construction of the bridge, exclusive of interurban electric train service. The financing of interurban service has subsequently been legalized by Congressional Act of 1934, but has not yet finally been approved by the Reconstruction Finance Corporation pending presentation of plans and estimates to be submitted in December, 1934.

Section 3

Federal and State Authorities and Personnel

Reconstruction Finance Corporation—

Jesse H. Jones, Chairman
Henry Morgenthau, Jr., Director ex officio
Charles B. Henderson, Director
C. B. Merriam, Director
Frederic H. Tabor, Director
Hubert D. Stephens, Director
Charles T. Fisher, Jr., Director
Morton Macartney, Chief Engineer
Henry A. Mulligan, Treasurer
George R. Cooksey, Secretary
Harry E. Whitaker, Special Engineering Advisor

Hoover-Young Commission—

Mark L. Requa, Chairman
George T. Cameron, Vice Chairman
Rear Admiral Luther E. Gregory, U.S.N.
Rear Admiral W. H. Standley, U.S.N.
Brigadier General G. B. Pillsbury, U.S.A.

Lieutenant Colonel E. L. Daley, U.S.A.
Senator Arthur H. Breed
Charles D. Marx
C. H. Purcell, Secretary

California Toll Bridge Authority—

Frank F. Merriam, Governor
George J. Hatfield, Lieutenant Governor
Earl Lee Kelly, Director, Department of Public Works
A. E. Stockburger, Director, Department of Finance
Harry A. Hopkins, Chairman, Highway Commission

Department of Public Works—

Earl Lee Kelly, Director

San Francisco-Oakland Bay Bridge Division—

Earl Lee Kelly, Director, Department of Public Works
C. H. Purcell, Chief Engineer
Chas. E. Andrew, Bridge Engineer
Glenn B. Woodruff, Engineer of Design
Charles A. Marsh, Chief of Right of Way
John W. Green, Assistant Designing Engineer on Concrete
James R. Kelsey, Assistant Designing Engineer on Steel
I. O. Jahlstrom, Resident Engineer, Contracts 2 and 6
N. W. Reese, Resident Engineer, Contract 3
V. A. Endersby, Resident Engineer, Contracts 4, 7 and 8
H. Carter, Resident Engineer, Contract 5
D. R. Warren, Chief, Triangulation and Surveys

Division of Highways—

Thomas E. Stanton, Jr., Materials and Research Engineer

District IV Approaches—

Colonel John H. Skeggs, District Engineer
Paul O. Harding, Senior Bridge Field Engineer

Board of Consulting Engineers—

Ralph Modjeski, Chairman
Moran and Proctor
Leon S. Moisseiff
Charles Derleth, Jr.
H. J. Brunnier

Board of Consulting Architects—

Timothy L. Pflueger
Arthur Brown, Jr.
John J. Donovan

Consulting Geologist—

Professor A. C. Lawson

Attorneys—

Heller, Ehrman, White & McAuliffe

CHAPTER No. II

Section 1

General Description of Project

The project consists of a bridge spanning San Francisco Bay from a point midway between Harrison and Bryant Streets in San Francisco, via Yerba Buena Island, to the shore line of Oakland. The main bridge structure is divided into two major parts, spanning the east and the west channels of San Francisco Bay.

The approved design for the West Bay structure consists of twin suspension bridges with a central live load anchor pier. Each of the center spans has a length of 2310 feet between towers, and the side spans a length of 1160 feet each; the total distance from shore to shore in the west channel being approximately 9000 feet.

The vertical clearance above high water at the San Francisco Harbor line and at the pier just west of Yerba Buena Island is 172 feet. This clearance rises with the grade of the bridge floor to a vertical height above high water of 214 feet at the central tower piers, and the full clearance of at least 214 feet is maintained for the full length of the two 1160-foot spans on either side of the center anchorage.

Clearances and Span Length

The approved design of the East Bay structure consists of a 1400-foot central span cantilever over the main East Channel with two 511-foot anchor arms and five 509-foot fixed spans extending eastward past the Oakland Harbor line and fourteen 291-foot fixed spans completing the structure to the end of the present Key Route fill. From the end of the Key Route fill, the bridge traffic will be carried by viaduct and widened fill to the Oakland shore line. The vertical clearance over the main channel is 185 feet above high water.

The portion of the project passing over Yerba Buena Island consists of a 540-foot tunnel under the crest of the island, and a steel and concrete viaduct extending from the east tunnel portal to the main cantilever over the east channel.

In San Francisco, automobile traffic will be carried by a concrete and steel viaduct to a plaza at Fifth Street, between Harrison and Bryant Streets, where traffic will be distributed to the existing street system of San Francisco. Ascending and descending ramps from the bridge will permit traffic destined to portions of the business district nearer the bay to leave the bridge on Fremont and First Streets, respectively. Interurban traffic is proposed to take off the bridge by an elevated viaduct to a passenger station on Minna Street between Fremont and Second Streets.

Drawing of West Bay Crossing

On the Oakland side, the project includes the toll plaza and administration buildings. The approaches which connect with the bridge head at the end of the Key mole fill are being financed and constructed by District IV, Division of Highways of the State of California. The entire project, when completed, will become part of the State Highway System.

Comparative Points of Greatness

This project surpasses all other bridges heretofore constructed in the following particulars:

It exceeds in cost all other bridges.

It spans the longest stretch of major navigable water heretofore bridged.

It involves the deepest foundations ever undertaken.

It includes the largest tunnel cross section yet constructed, and the first major twin suspension bridge.

SECTION 2

Design Data, Loadings and Traffic Capacity

Foundations

From the inception of the project, engineers have realized that the foundations of this bridge presented the most difficult subaqueous construction yet attempted. As a result, the problem has been attacked with extreme care both in foundation investigation and design.

Cost of Borings

A total of $135,308 was spent in borings. A careful study of the materials overlying rock, both as to its bearing power and resistance to caisson sinking, was made. Undisturbed samples of the various strata at a large number of points were taken and carefully tested for compressibility, water content, and general characteristics. A large number of diamond drill borings were taken into the underlying rock. The records of borings are extensive, and are available at the Bridge Office. As construction has progressed, excavation findings proved with a remarkably close check the accuracy of the boring results, both as to the character of material penetrated and depth to rock or other suitable foundation materials.

The great depth to rock in the West Bay or suitable foundation material in the navigable portion of the East Bay, excluded all types of foundation except some form of open caisson.

Drawing of East Bay Crossing

Detailed descriptions of the design of these caissons are given in succeeding reports on the Contracts Nos. 2 and 4-4A for the West and East Bay substructures.

A large number of piers with pile foundations were designed for the easterly portion of the East Bay crossing, which are also described in former publications.

Earthquake Resistance

All foundations are designed to withstand earthquake stresses equivalent to 10 per cent of gravity, in addition to dead and live load stresses.

Superstructure

The superstructure design contains several novel features.

The West Bay crossing, between San Francisco and Yerba Buena Island, is the widest stretch of major navigable water yet bridged. Reference to earlier reports will give the reader information on the great amount of design study which was necessary to reach an engineering conclusion as to the proper type of structure.

Twin Suspension Bridges

The type of structure adopted is a twin suspension bridge, symmetrical in its major particulars east and west from a central anchorage. The central anchorage acts only to resist unbalanced live loads, the dead load being transmitted through the anchorage by eyebars. This detail is new in major suspension bridges, and constitutes a new step in design.

The major design problem in the East Bay portion of the project was the 1400-foot cantilever span. This span is the third longest cantilever in the world, and consideration of earthquake stresses further complicated the design.

Double Deck Throughout

In general, the bridge superstructure is double-deck in cross section, with provision for six lanes of fast traffic on the upper deck and three lanes for heavy trucks and two interurban electric tracks on the lower deck. The bridge is designed for a total live load of 7000 pounds per foot.

Traffic on the upper deck will be restricted to passenger automobiles and light trucks, floors being designed for a 15-ton truck at any point.

The lower deck truck lanes are designed for 40-ton trucks, and the car tracks for 1000 pounds per foot of track. For details of design, reference is made to former reports and Engineering News articles, Series 1934–35.

Section 3

Contracts

Contract	*Date Signed*	*Date Filed*
2	May 10, 1933	May 19, 1933
3	May 10, 1933	May 19, 1933
4	May 10, 1933	May 19, 1933
5	May 10, 1933	May 19, 1933
6	May 10, 1933	May 19, 1933
7	May 10, 1933	May 19, 1933
8	Jan. 13, 1934	Jan. 22, 1934

(For items of contract and bids see Appendix.)

Section 4

Construction Progress

West Bay Substructure

(Contract No. 2)

Contract No. 2 includes building Piers W2, W3, W4, W5 and W6[1] of the West Bay Crossing and changes required at San Francisco Harbor Dock No. 24 to accommodate Pier 2 location.

Actual construction was started during May, 1933, with demolition of the end of Harbor Pier 24, preparatory to construction of Pier W2. Since June, 1933, and excepting legal holidays, the contractor has worked continuously twenty-four hours in each day for every day of the month. Sufficient men are employed in shifts to effect this program and to comply with the State's program for maximum spread of work by limiting the hours for any workman to thirty per week. The peak rate of construction was reached during December, 1933, and February, 1934, in each of which months more than 12 per cent of the contract was completed. Today, slightly more than one year later, the Transbay Construction Company has successfully completed 95 per cent of its contract including all the hazardous work of founding and sealing the largest and deepest piers in the world.

Building of the West Bay piers can be considered under two general classifications, according to type of structure, which are governed by the physical conditions at each pier site and by the adopted construction method. All piers supporting the steel towers are built to a height of 40 feet above datum at mean lower low water. The central anchorage pier, under this contract, is built to the lower deck level 235 feet 2 inches above datum. (Superstructure Contract No. 6 carries it to 281 feet 9 inches above datum.)

Sheet Pile Cofferdam

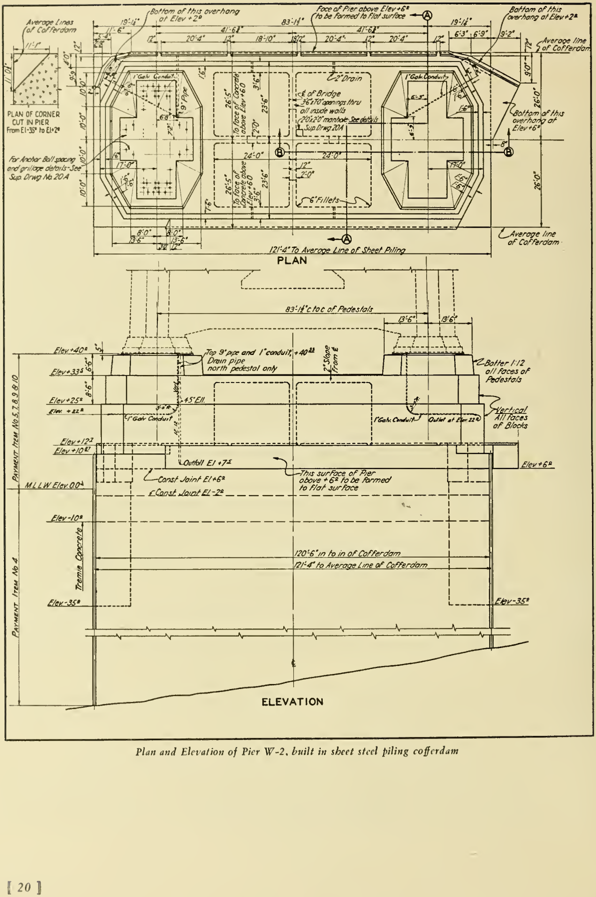
Pier W2, which supports the most westerly steel tower for the suspension spans, was the first one completed. This pier was built by means of a braced steel sheet pile cofferdam constructed according to standard practice. Water at this pier averaged about 55 feet, with some 33 feet of mud and clay overlying average bedrock at 88.6 feet below mean lower low water datum. Materials over the pier area were first removed by dredging to 80 feet, after which timber falsework piles were driven and guide wales or horizontal timbers placed to enclose a cofferdam 52 feet by 121 feet 4 inches in plan dimensions. Interlocking steel sheet piles were then driven into bedrock along the line defined by the sides and ends of the rectangle with the dimension noted. Tops of the sheet piles extended some ten feet above low water.

The cofferdam was braced inside by heavy timber frames spaced 15 feet on centers vertically and 17 feet on centers horizontally, forming 21 wells through which mud and clay could be dredged and bedrock surface cleaned in preparation for seal concrete. Dredging to bedrock was completed on September 10, 1933, with final rock elevations ranging from 78.4 to 101.1 feet below datum.

Rapid Concrete Pouring

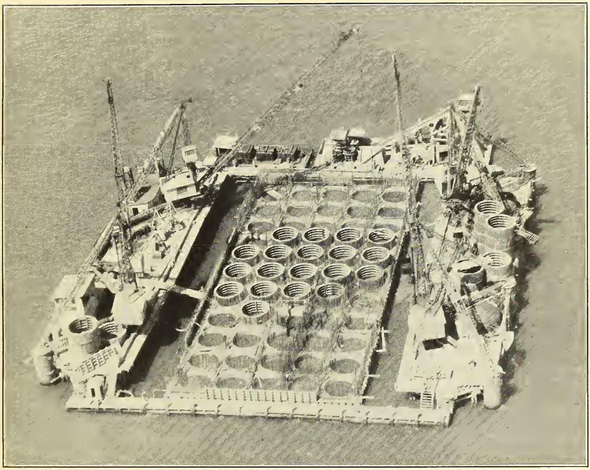
The outstanding feature of this pier was the pouring, in slightly over nine days, 18,800 cubic yards of concrete into a continuous seal block 52 feet by 121 feet 4 inches in plan and averaging 79 feet in thickness. Special bottom dump

[1]For key to pier or unit numbers see Plan and Elevation, Appendix A.



Plan and Elevation of Pier W-2, built in sheet steel piling cofferdam

buckets were used to place this underwater concrete which was completed on September 21, 1933. The entire pier, totaling 25,624 cubic yards of concrete, was completed to elevation 40 feet above datum on December 1, 1933.



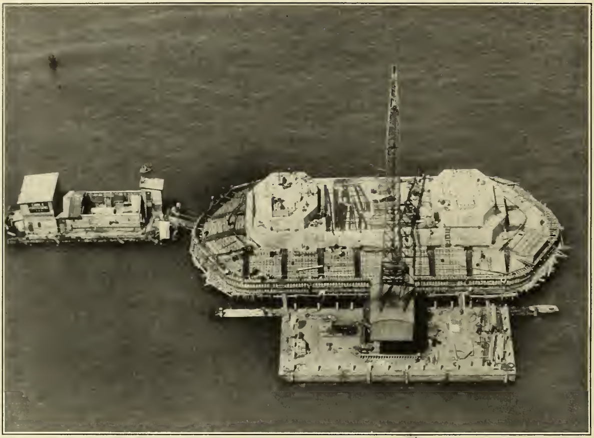
Pier W-4, the Concrete Anchorage, after sealing to rock at 216 feet below water

The concrete pier tops were ground off to a level plane with a maximum tolerance of 1/16 of an inch.

The major portion of the foundation work under Contract No. 2 involves building the central anchorage designated as Pier W4, the two adjacent tower piers W3 and W5, and the final tower pier next to Yerba Buena Island, designated as Pier W6. The caisson for each pier consists of a cellular steel and timber box rectangular in plan. This box is pierced by vertical steel cylinders 15 feet in diameter, open at the bottom, and joined by adaptor sections to narrow cross walls spaced on 17-foot centers each way and terminating 5 feet 5 inches above the cutting edge section for the outside walls of the caisson. Each cylinder is capped at the top with a steel dome. Air is pumped into these domed cylinders to displace water and thus give added buoyancy to the caisson during flotation and early sinking stages through the soft mud overlying clay and the deeper bedrock. **Compressed-Air-Flotation Caisson**

As units consisting of pours of concrete, with lifts of cofferdam and sections of 15-foot steel pipe are added to keep the top of the structure above water, the caisson is sunk by releasing air and removing a few domes at a time, dredging materials

from the wells, replacing the domes, pumping up with air, and continuing this cycle until the caisson is sunk to stiffer materials overlying bedrock. Air pressures are then gradually reduced, domes removed, and dredging from the wells continued in the ordinary manner until the caisson is founded on bedrock. The caisson in this phase is an "Open Well Dredging Type."



Pier W-6 with timber forms for concrete fender

Advantages of New Type of Caisson

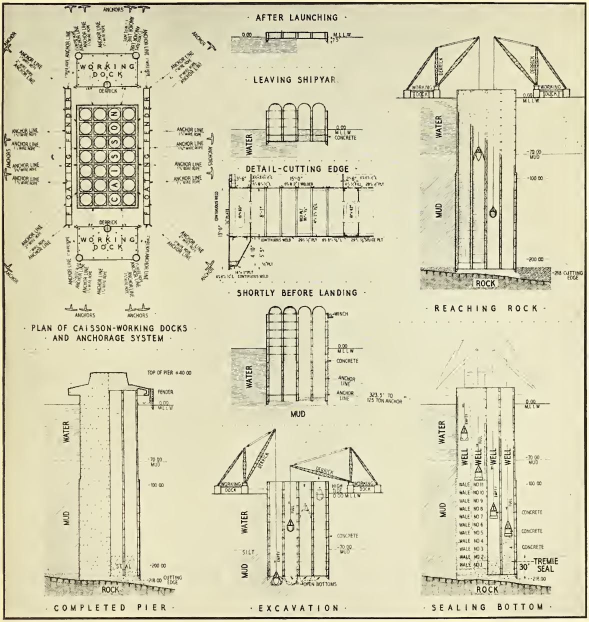
Reduced construction risk is effected through the increase of caisson stability, or resistance to tipping, attained by manipulation of air pressures in selected groups of cylinders over the caisson area. Effects due to unbalanced construction loads, or to unequal bearing power of the softer materials overlying bedrock may thus be readily corrected. A further noteworthy advantage is secured during the transition, or landing stage, when the caisson changes from a floating structure to one partly afloat and partly aground. At this time, manipulation to and landing of the caisson in its true lateral location is essential as it will practically maintain this same lateral position in its progress to bedrock. This has proved true even though the caisson may penetrate more than one hundred and fifty feet of mud, clay, sand and gravel in its passage to bedrock.

Buoyancy Control of Caisson Provided

The ability to take ample time in bringing the floating caisson to correct lateral position, with the cutting edge just above bottom, and then suddenly dropping it into the mud and clay by a quick release of air gives a very material advantage. This is readily realized when one considers the vagaries of wind and currents in the tidal races west of Yerba Buena Island.

W-3, West Bay Deepest Pier

Tower Pier W3, 2310 feet east of Pier W2 and on the east side of the main westerly ship channel, is 74 feet 6 inches by 127 feet in plan dimensions, contains 28 cylinders or dredging compartments, and is founded on bedrock with an average depth of 231.2 and a maximum depth of 240.7 feet below mean lower low water



Operations in Sinking Caissons and Constructing Piers

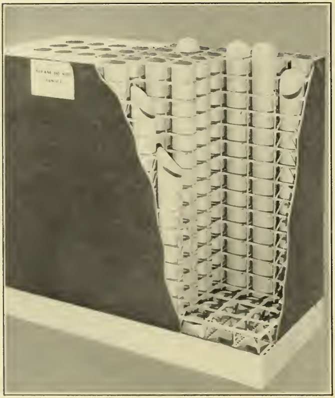
datum. It is now the deepest pier in the world, though it may be exceeded by one of the East Bay piers. Construction of Pier W3 was started on September 9, 1933. The caisson was towed from Moore Dry Dock to the site in December, 1933, and was landed on January 20, 1934, in 73 feet of water. It was sunk to a final cutting edge elevation of —223.8 feet and founded on bedrock at an average elevation of 231.2 feet below datum. The concrete seal was completed by June 2. The pier was completed to an elevation of 40 feet above datum by June 30 and will be ready for tower steel erection about the middle of July. The cellular concrete fender will be omitted for the present so that tower steel erection may be complete in time for cable spinning operations when the central anchorage pier is finished.

Pier W-5
Depth 110.7 Feet

Tower Pier W5, on the westerly side of the main 2310-foot ship channel adjacent to Yerba Buena Island, is 57 feet by 127 feet in plan dimensions, contains 21 cylinders or dredging compartments and is founded on bedrock at an average depth of 110.7 feet below datum. Construction for this pier was started on October 16, 1933. The caisson was towed from Moore Dry Dock to the site on March 18, 1934, and was landed on April 10, 1934, in 70 feet of water. It was sunk to bedrock and sealed by June 4, 1934, and will be completed to 40 feet above datum by July 3 with the exception of the fenders.

Pier W-6
Average Depth 171.7 Feet

Tower Pier W6 has been completed with the exception of the timber fenders. This is the pier adjacent to Yerba Buena Island and is distant 2310 feet from Tower Pier W5. It is 74 feet 6 inches by 127 feet in plan dimensions, contains 28 cylinders or dredging compartments, and is founded on bedrock at an average elevation of 171.7 feet and a maximum elevation of 177.5 feet below datum. Construction for this pier was started on June 12, 1933. The caisson was towed from Moore Dry Dock to the site on October 10, 1933. It was landed on December 11 in 105 feet of water, and was sunk to bedrock and sealed by April 13, 1934. The pier was completed to elevation 40 feet above datum by June 8, excepting minor timber fender construction, which is rapidly nearing completion.


Model of Caisson for Pier W-4 showing steel cutting edge bottom, caulked timber, steel cylinders and domes used during floating stage

Central Anchorage Pier W4, midway between Tower Piers W3 and W5, is the largest pier in the world. It is 92 feet by 197 feet in plan dimensions, contains 55 cylinders or dredging compartments, was landed in 71 feet of water and founded on bedrock at an average elevation of 216.0 feet below mean lower low water datum. Construction for this pier was started on June 26, 1933. The caisson was towed from Moore Dry Dock to the site on November 8, 1933, and was landed on the bay bottom on December 22, 1933. It is now being founded on bedrock at an average elevation of 216.0 feet below datum. The first block of seal concrete has been placed in the central area comprising 25 of the 55 cylinders. Cleaning of bedrock surface in preparation for the two remaining seal blocks is well under way at the present time. All seal concrete will be completed during July and the entire pier and concrete superstructure to the lower roadway level will be completed before the end of this year.

A few detailed construction features in connection with the building of this unique pier may prove interesting. Similar comments apply to the other piers of

Contract No. 2. These features will be considered under five headings as follows:

1. Construction of the caisson at dry dock.
2. Construction at the pier site during flotation.
3. Construction during dredging and sinking to bedrock.
4. Founding and sealing of the caisson.
5. Completion of the pier structure.

Chronology of Caisson Construction

Drydock construction was effected at the Moore Dry Dock Company plant on the Oakland Estuary. A steel cutting edge section of structural shapes was riveted and welded together on the launching ways to a height of 17 feet 6 inches and with plan dimensions, as noted, of 92 feet by 197 feet. The section was then launched and floated alongside one of the shipyard wharves where it was moored convenient to one of the traveling yard cranes. A structural steel frame of heavy I-beam wales with steel angle vertical and bracing members was then added above the planes of the outside and cross caisson walls. Vertical 10-inch timbers, starting along the outside wall of the cutting edge, spanned the distances between wales. These timbers, together with the outside watertight diagonal sheathing layer of 4-inch caulked timber formed the outside shell of the caisson. Inside this shell steel cylinders 15 feet in diameter were extended upward from the adaptor sections and capped with steel domes. The structure was built in this manner to a height of 77 feet 6 inches above the cutting edge. Concrete was placed in the outside and cross walls of the cutting edge section to give added stability when the caisson was towed to the pier site.

Launching at Moore Dry Dock

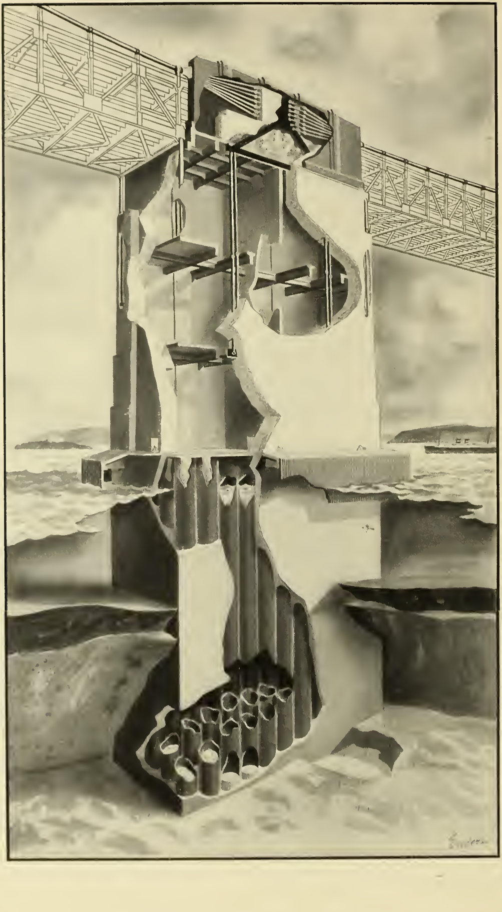
During this period two construction docks supported on piles were built at the pier site; one north and one south of the pier area. Each dock was equipped with two stiff-leg derricks of 20-ton capacity mounted on special cylinder foundations. Twenty-six anchors for holding the caisson were placed in the bay bottom at distances of approximately 350 feet from the caisson sides.

Caisson Construction Docks

Upon completion of this work, ocean-going steam tugs towed the caisson from the shipyard to the pier site where it was maneuvered into position between the construction docks. At this stage the caisson had a draft of about 20 feet and towered 57 feet above the water surface; in technical language, has a freeboard of 57 feet. Anchor tackles were immediately attached and sinking operations begun. This was effected by adding 5 to 15-foot layers of concrete in the spaces between well cylinders and between cylinders and outside walls of the caisson. As concrete was added, air pressures were gradually increased to maintain a minimum draft. This was held until concrete had hardened sufficiently to withstand the greater pressures when the cutting edge was lowered by partial release of air. When the structure was sunk thus to a minimum freeboard of about 15 feet, steel and timber walls and interior steel framework were added in units of 10 to 20 feet in height. Air was released in 5 to 7 of the 55 cylinders, domes cut, cylinder extensions welded into place and redomed at the higher level. Air was added to these cylinders and the cycle repeated until all cylinders had been extended. With this new height of structure, concreting and sinking were continued as previously described. This cycle of building and sinking was repeated until the cutting edge was only a few feet above the bottom. At this stage the caisson had a total height of 117 feet, 6 inches, a draft of 63.1 feet and a weight of about 30,700 tons. Twenty-two pounds of air pressure were required in each cylinder to keep the caisson afloat in readiness for the next or landing phase of pier construction.

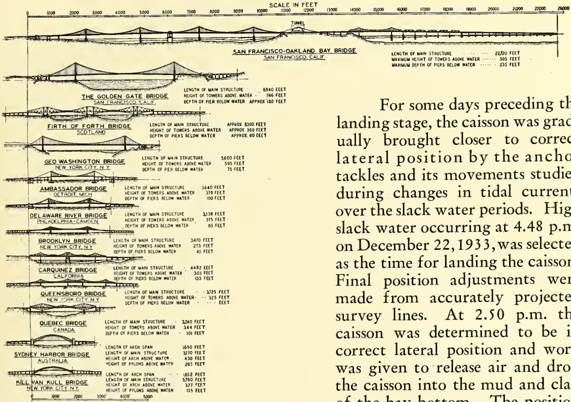
Caisson Floated to Site

Caisson Building Cycle



Artist's conception of Concrete Center Anchorage cut away to show construction

GRAPH
COMPARATIVE DIMENSIONS OF THE
SAN FRANCISCO-OAKLAND BAY BRIDGE
AND THE WORLD'S LARGEST BRIDGES



For some days preceding the landing stage, the caisson was gradually brought closer to correct lateral position by the anchor tackles and its movements studied during changes in tidal currents over the slack water periods. High slack water occurring at 4.48 p.m. on December 22, 1933, was selected as the time for landing the caisson. Final position adjustments were made from accurately projected survey lines. At 2.50 p.m. the caisson was determined to be in correct lateral position and word was given to release air and drop the caisson into the mud and clay of the bay bottom. The position was constantly checked during lowering and any deviation quickly corrected by manipulation of the proper anchor tackles. The caisson was landed by 5.00 p.m. within less than one foot of the designed location. The final cutting edge elevation was 78.6 feet below datum giving an average mud penetration of 7.2 feet. About 6000 tons of buoyancy was removed by release of air during the landing.

Landing Caisson in Mud

After landing, concrete, structural steel, and cylinders were added as in the flotation stages with the difference that cutting edges and cross walls were undercut by removing mud and clay through the dredging wells when domes were removed. Gradually, as the caisson was sunk into stiffer materials nearer to bedrock, air pressures were released and domes removed entirely. Dredging was then continued through the open wells and the caisson sunk to its final cutting edge elevation of 210.2 feet below datum by June 11, 1934. This completes the third construction stage.

Dredging Through Open Wells

Due to the difficulty of holding the caisson at a definite elevation, as the cutting edge is undercut during final cleaning, seal concrete was scheduled for placement in three separate blocks. Following this program, the area covered by the central 25 cylinders was carefully cleaned to bedrock surface. Powerful water jets, working under pressures of 300 to 350 pounds per square inch, broke down walls between dredging wells and freed the cutting edge of any mud to assure close contact between steel, concrete, and bedrock. Suction pumps, with inlets just above bedrock, removed fine sand and mud. Final digging with toothless dredging buckets removed broken-up jetted material and the last loose rock fragments overlying bedrock. During this period frequent diver inspections were made to facilitate

Inspection by Diver of Jetting Results

cleanup. Final inspection was made just before the start of seal concrete. It should be noted that daily inspection dives in water depths up to 220 feet are in themselves almost unprecedented feats.

Concrete Seal Placed by Bottom Dump Buckets

Seal concrete was started in the central area on June 17, 1934, from average bedrock at 216.0 feet below datum. It was completed to 34.0 feet above the cutting edge on June 20, 1934. Special bottom dump buckets were used to place the 8200 cubic yards of concrete in this seal. Cleaning of the end seal areas is progressing rapidly and the entire seal will be completed during July.

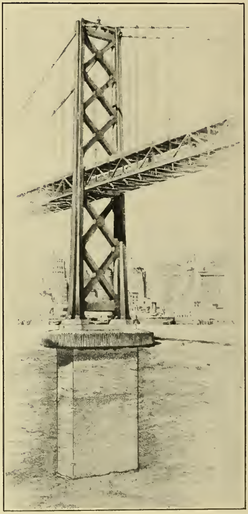
The last stage involves the building of the pier above water to its final elevation. This concreting proceeds by ordinary construction methods and has none of the hazards occurring in the earlier caisson stages. The present top of Pier 4 is about 7 feet above datum. The pier will be completed to the top of lower roadway late this year.

West Bay Substructure Quantities Used to Date

Construction of West Bay piers to date has involved the use of 203,000 cubic yards of concrete, 3900 tons of structural steel, 4200 tons of reinforcing steel, and some 4,000,000 board feet of timber.

Equipment Equals 25% of Contract Cost

Work of the magnitude described requires for its construction correspondingly large scale equipment; in fact the value of construction docks and equipment may exceed 25 per cent of the contract cost for building foundations. Of course much of the equipment has a high salvage or reuse value.



Artist's conception of proportion of Pier W-3 and tower it supports

Equipment

Large Derricks Required

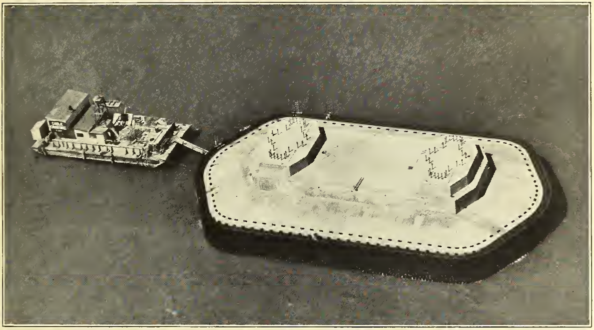
At Pier W2, most of the construction work was handled by two stiff-leg derricks mounted on clusters of creosoted piles driven at the end of Harbor Pier 24. One derrick was equipped with a 110-foot, and the other with a 120-foot boom. Lifting capacity was 30 tons for a short radius and 15 tons on a 90-foot radius. Each crane was powered by electricity at 440 volts using a 150 horsepower motor on the three drum hoists, a 25 horsepower swinging motor and a braking motor. Loads could be lifted or lowered at the rate of about 150 feet per minute.

After the construction of Pier W2, these derricks were dismantled and moved to the site of Pier W4 where they, and two others, were mounted on special temporary timber pile and concrete cylinder foundations. These four derricks handled pier construction from the time the caisson was floated into position, and will be used until the pier is completed to a top elevation of +235 feet, maximum height of

concrete. Two additional stationary cranes or derricks were mounted on similar pile and concrete foundations for constructing Pier 3.

Floating Equipment on Two West Bay Piers

Construction of Piers W5 and W6 called for floating equipment instead of the stationary rigs as used at Piers W2, W3 and W4. Two special whirley, or revolving derricks, were mounted on 49-foot width by 105-foot length by 10½-foot depth barges. Each derrick had approximately the same capacity and speed as the stationary derrick rigs. These two rigs were first used to build Pier W6 and were then moved over to construct Pier W5.



Aerial photo of completed Pier W-6 typical of Piers W-3 and W-5

Before any of these electric rigs were used at the piers, an 11,000-volt armored submarine power line was run from the San Francisco shore to Yerba Buena Island and connections made for each of the four channel pier sites where stationary mounted, or floating transformer banks reduced the voltage for the electric machines. Power was supplied from either or both ends of this submarine line to avoid possible shutdowns, especially during placement of the tremie concrete seal. To date, only a few very minor delays have been experienced from loss of power.

100-ton Anchors Hold Caissons

The sixty-four 100-ton capacity and twenty-four 125-ton capacity concrete anchors with their connecting cables and tackles are unique both in size and in method of placement down into the bay bottom by means of powerful water jet systems incorporated in the anchors and supplied through fire hoses with water at a pressure of 300 pounds per square inch.

In addition to the heavy equipment mentioned above, and excluding concrete plant or apparatus, there were numerous other pieces of both special and ordinary equipment including, at Pier 24, complete machine, welding, blacksmith, rigging, carpenter, and electric shops.

Floating Equipment Listed

Among the other special items there should be mentioned the two floating work derricks with a maximum capacity of 12 tons, or 5 tons at a radius of about 40 feet. Further floating equipment consisted of the water and oil barges, lumber, transformer, and compressor barges and the fleet of tow and work boats required

to handle men and equipment. Of this fleet, the *Hercules* was the largest with a 300-hp. Diesel engine and the *Monovalve,* the smallest, with a new type single valve per cylinder 25-hp. Diesel engine. The other boats were the *Tango,* 210-hp. Diesel engine, *Anadir,* 160 hp. Diesel engine, and *Margarita,* with a four-cylinder gasoline engine.

Air Compressors Perform Important Work

Air compressors of 250 to 1800 cubic feet capacity operated by motors or engines up to 300 hp. were used to supply air pressure to the caisson cylinders and to operate the various small tools. Water pumps for cleaning, jetting, or dewatering operations ranged from low head, high capacity machines used at Pier 2, to pumps operated by engines ranging to 300 hp. and delivering water at pressures up to 300 pounds per square inch. A diving barge with a decompression chamber, 3½-cubic yard dredging buckets, 4½-cubic yard bottom dump concrete buckets for placing tremie concrete, and electric welding machines formed further items of expensive equipment. Power for the electric welding was given by 20 hp. motor-generator sets which supplied welding current at 40 volts and up to 300 amperes.

In the smaller pieces of equipment there should be mentioned the hand winches of 10-16 tons capacity used to control the anchor tackles of the caissons during the flotation and landing operations. Air vibrators operating at 3500 vibrations per minute on 100 pounds air pressure were used to compact the concrete. Small tools as air drills, hammers, etc., were also used to expedite the work.

Automatic Mixing Barges

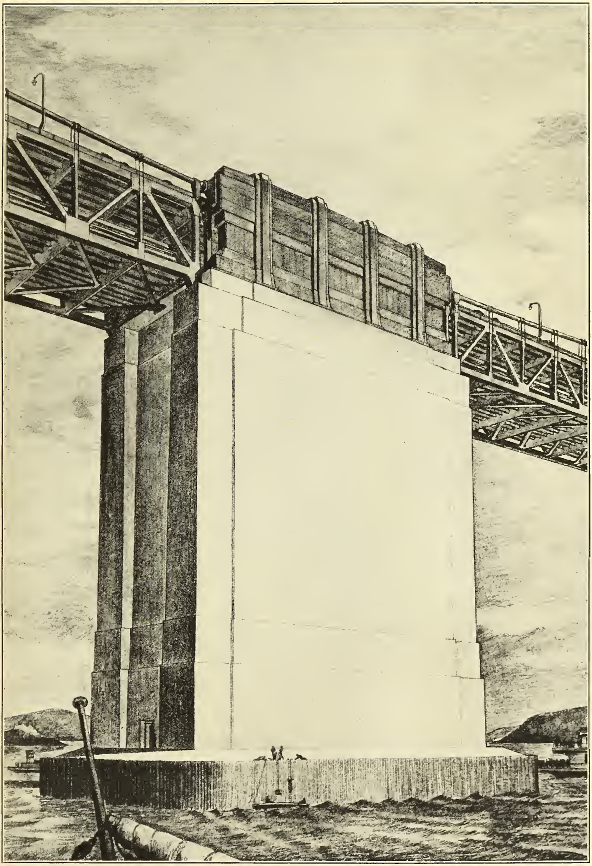
The speed of foundation construction of the nature described is to a large extent limited by the speed and adequacy of concrete delivery and placement. In order to reduce the floating equipment at each pier site, and to economize on plant cost, a central storage and batching plant was established on the Oakland water front to serve both east and west bay pier construction. Dry cement and aggregates were weighed out in the proper proportions at this plant and then loaded into special bins on barges equipped with concrete mixers. These barges were towed to the desired piers, where the cement and aggregates were mixed together into plastic concrete which was delivered in various ways for placement into the caisson or pier.

Each of the six concrete barges was approximately 38 feet by 105 feet in plan dimensions and held eighty 3½-cubic yard batches of dry proportioned cement and aggregate. At the pier site the dry materials were delivered by conveyor belts to the mixers mounted at one end of the barge, one belt for each pair of mixers. Mixing time was a minimum of 3½ minutes per batch.

After the materials were mixed they were dumped onto a single wet conveyor belt and run to the opposite end of the barge where a shuttle, or cross belt, delivered the plastic concrete to a hopper on an adjoining or intermediate delivery barge.

Concrete Pumps Employed

During the stages of floating construction, conveyor belts on the delivery barge carried the concrete to an agitating hopper from which position it was admitted to the concrete pumps. These pumps in turn forced the concrete through 8-inch diameter pipes to the desired place inside the caisson. The advantage of this method was that the delivery pipe could be run through the side wall of the caisson above the water line and concrete delivered and placed while the structural steel, or timber sides were being raised. Later in the work, after the caissons were grounded, concrete was taken from the intermediate delivery barge and raised by buckets and derricks to the proper place in the pier. A maximum of over 100 cubic yards per hour was delivered in the manner described though the normal sustained rate was about half or two-thirds of this amount. Final delivery of concrete for the superstructure of Pier W4 will be from barge to a timber elevator tower and thence by buggies to placement in the structure.



Architectural drawing of Pier W-4, Center Anchorage

In conclusion, it should be restated that without both ordinary and special equipment, foundation construction of the type considered would not be possible. With equipment valued in the millons of dollars on this job its intelligent use and its importance are evident.

The associated companies comprising the Transbay Construction Company are:

General Construction Company, Seattle.
Morrison Knudson, Boise.
McDonald and Kahn, San Francisco.
Pacific Bridge Company, Portland.
J. F. Shea Company, Portland.

San Francisco Cable Anchorage and Short Piers

(Contract No. 3)

Contract No. 3, embracing that portion of the main bridge structure in San Francisco, between Rincon Hill and The Embarcadero, was finally approved and delivered to the Healy-Tibbitts Construction Company of San Francisco on May 19, 1933. Included in the contract are the San Francisco Cable Anchorage, the Viaduct structure between the Anchorage and Rincon Hill, Piers "A" and "B," Pier W1, and the demolition of the buildings on the right of way between the Viaduct and the westerly side of Main Street.

Cable Anchorage

San Francisco Cable Anchorage Dimensions

The Cable Anchorage, a concrete structure, 184.5 feet long, 108 feet wide, rising, when completed, 148 feet above the neighboring streets, will contain approximately 68,000 cubic yards of concrete and 1200 tons of steel. In addition to the function of anchoring the westerly end of Suspension Bridge cables, it marks the end of the steel section of the bridge superstructure and the beginning of the long concrete approaches to the San Francisco terminals.

S. F. Cable Anchorage Bedrock —5 to —25

The site, near the northwest corner of Beale and Bryant streets, was cleared of buildings by June 22, 1933, and the excavation for the foundation was started immediately, a one and one-half yard gas electric and a one-yard steam shovel being used. By September 17, 1933, the excavation had been completed, bedrock being encountered at approximately the elevations shown on the contract drawings—*i.e.,* at Elevation —5 to —10 along the easterly face and at Elevation —10 to —25 along the westerly face. Beale Street is 14 feet above zero datum at the Anchorage.

Concrete Operations on S. F. Anchorage

During the period occupied by the excavation the Contractor constructed a concrete mixing plant and aggregate storage yard along the southerly side of the Anchorage site. The plant has a capacity of twelve hundred yards in twenty-four hours. The proportions of the mix are controlled by full automatic weighing and measuring devices, all entirely under the direct control of a concrete technician, a member of the Bay Bridge engineering staff. This arrangement, in addition to giving a most accurate control of the mixture and strength, eliminates the "human element" and other difficulties presented by a "hand" operated plant.

Preliminary operations were completed on the third of October and concreting started on the fourth. To transport the concrete from mixing plant to structure the contractor used a four-yard bottom dump bucket, handling the

bucket with a guy derrick erected near the center of the Anchorage block. After being deposited in the forms the concrete was compacted into place by internal vibrators.

Concreting operations continued until December 22, 1933, when the pouring stopped to permit the erection of the structural steel grillage used for anchoring the bridge cables into the concrete block. The erection of the grillage, comprising more than 700 tons, was completed on February 12, 1934, and concreting operations were resumed.

By May 24, 1934, pouring of the first section of the Anchorage was completed, a total of 33,500 cubic yards of concrete having been placed. There will be no further work performed on this section of the contract until after the cable spinning operations are completed.

Viaduct

Work on the Viaduct section, a series of five, sixty-five foot, double deck, reinforced concrete spans, varying in height from 30 feet at the westerly end to 90 feet at the easterly or Anchorage end, started upon the completion of the first section of the Anchorage.

San Francisco Viaduct Elevations

At present the excavation for the foundations is thirty-five per cent complete. This section is scheduled to be completed during the early part of this coming year.

Piers "A"-"B"

Piers "A" and "B", located on the westerly and easterly sides of Main Street, respectively, will form the center support for the structural steel bridge structure between the Anchorage and Pier W1.

San Francisco Shore Piers

To date, work is under way at Pier "B" only. The interlocking steel sheet piling forming the cofferdam walls have been driven to grade and the placing of the cofferdam bracing frames, along with the excavation, will be started shortly.

The construction of Pier "A" will get under way when Pier "B" has been completed. Present plans call for the completion of both of the piers early in 1935.

Pier W1

Pier W1, located directly north of Bryant Street, between Spear Street and The Embarcadero, will be constructed entirely of reinforced concrete, covering an area 56 feet east and west by 112 feet north and south, and, when completed, will rise to elevation plus 188, or approximately 176 feet above the street surface on The Embarcadero. It marks the western end of the Suspension Bridge spans, forms a cable support and terminates the truss spans between the Anchorage and Pier W1.

Pier W-1 has Cable Support at Side Span End

The site was cleared of railroad trackage by September 29, 1933, and the contractor started the excavation for the foundation on the same date.

After the removel of the surface fill material to Elevation 0.0, approximately 12 feet below the street surface, the first cofferdam timbers and frames were placed

Architectural conception of San Francisco Anchorage when completed

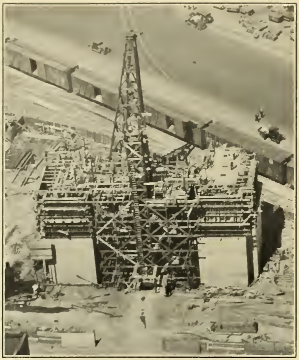


Photo of Pier W-1 in construction

and interlocking sheet piling were driven through the underlying mud and clay into the bedrock strata below. The excavation was continued inside of the cofferdam thus formed, additional bracing frames being placed as required, and, although the pressures experienced were rather high, no great difficulties developed, due to the care used in prosecuting the work. Bedrock was cleaned to Elevation —20 at the northerly end and to Elevation —60 at the southerly end.

Concreting operations, carried on in progressive stages with the excavation, have been completed to Elevation +28, sixteen feet above street grade, the concrete being transported from the plant at the Anchorage to the site in motor trucks.

Pier W1 is scheduled to be completed to Elevation +143, the point at which the cable bent will be erected in adequate time for the spinning operations that follow.

The contractor is Healy Tibbitts Construction Co., the officers of which are: Charles C. Horton, President; J. H. Edwards, Secretary-Treasurer.

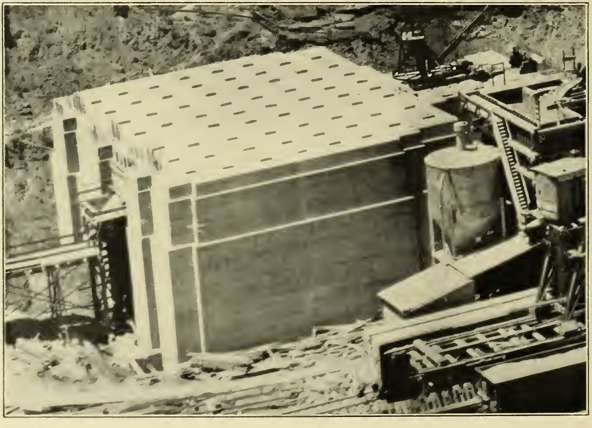


Photo of first stage of construction of San Francisco Cable Anchorage with approximately 35,000 thousand cubic yards of concrete placed

East Bay Substructure

(Contract No. 4)

General Description of Work

This Contract comprises Piers E-2, E-3, E-4 and E-5 of the East Bay Crossing of the bridge.

Piers E-2 and E-3 are the main supporting piers of the cantilever span. Pier E-1, western anchor pier for the span, is under another contract. Pier E-4 is the eastern anchor pier corresponding to E-1, and Pier E-5 is the last of the caisson type piers on the bridge counting from west to east.

Pier E-2 is situated just off the shore of Army Point, Yerba Buena Island.

Included in the contract is an item for rebuilding a wooden island dock of the United States Army, the original dock interfering with the construction of E-2.

Piers E-4 and E-5 are complete except for part of the fender work. Pier E-3 has been sunk 175 of its 230 feet below sea level or Elevation 0.0.

Only preliminary work has been done on Pier E-2.

Details of Construction

Reinforced Square Well Open Caisson Type Piers

Piers E-3, E-4 and E-5 are all of the reinforced concrete, square well, open caisson type. The work was started by constructing a cutting edge of structural steel, divided into wells by heavy cross walls, the outside lines of the pier being formed by the cutting edge proper, which is a section beveled 45 degrees on the inside. Cross walls and cutting edge were built hollow and constitute the forms for the first pour or "lift" of concrete. These cutting edges were built in dry dock by the Moore Dry Dock Company, and the open wells fitted with heavy timber bottoms furnished with a "trigger" construction of such nature that they could be loosened by pulling on a cable from the top.

East Bay Caissons Held by Steel Piling

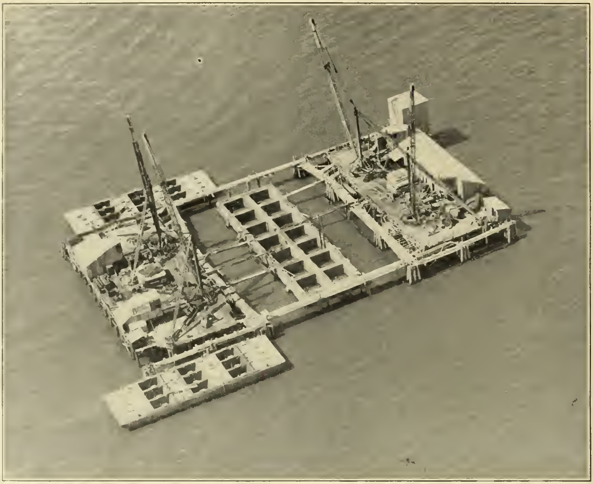
After launching, the first lift of reinforcing steel was set in the cutting edge and it was towed to the site. Here working and machinery platforms had previously been installed. The caisson was towed into a dock formed by six heavy steel piling driven into the mud; two more were driven behind it to hold it in place, accuracy of position being further insured by anchoring in four directions. The pouring of concrete then began, the caisson sinking toward the bottom of the bay as successive lifts of concrete were placed. Until the caisson was bedded in mud a strong outside wooden cofferdam was carried up upon the cutting edge, as the water level, after the first pour of concrete, was above the concrete. This cofferdam remains permanently in place. The inside forms consist of standard sections of sheet steel reinforced with angle bars, which were withdrawn and raised for successive pours.

False Bottom Caisson Sinking Method

After the wooden bottoms were well bedded in the mud at the bottom of the bay, the wells were filled with water and the bottoms withdrawn, the caisson immediately sank a considerable distance as the mud rose in the wells. The mud was then dredged out of the caisson with 2-yard clamshell buckets, dumped into the wells of bottom-dump scows, and hauled to designated dumping grounds. As the mud was dug out, the caisson sank proportionately until final grade was reached.

In the heavy concrete walls there were installed a double jetting system of pipes with multiple tips passing through the steel outside and inside of the cutting edge. The inside jets, or "cutting jets," through which water was forced when

nearing final grade served to clean out under the cutting edge to secure a large opening for the concrete base. Outside jets or "relieving jets," discharged air around the outside of the caisson for the purpose of breaking up the friction between the mud and the caisson outside wall, thus facilitating sinking. As a further aid,



Pier E-3 built in open dredging well caisson with half of its wells submerged below water line

an anti-friction preparation was applied to the cofferdam and later to the successive lifts of concrete. The preparation, which was immediately applied after forms were stripped from concrete, also serves as a cure coat, new concrete suffering by too rapid evaporation of water after pouring unless imperviously coated or kept wet. Curing of the inside walls was done by spraying on sodium silicate mixture or "water glass," which effectually prevents evaporation. Forms were stripped in from 18 to 24 hours after concrete was placed.

ncrete Seal Poured
neath Caisson

After reaching safe bearing material a large seal chamber was formed under the caisson by excavating the material from under cross walls and cutting edge, by the combined use of clamshell buckets and special jets. This space was then filled with concrete lowered to the bottom of the wells in submarine or "bottom dump" buckets; this concrete, which was poured in a very plastic mix, flowed under cross walls and cutting edge to form a solid supporting block or "seal" for the pier and its load. This seal was brought up from 5 feet below to approximately 15 feet above the cutting edge. The wells from there up to sea level remain filled with water only.

In the case of Piers E-3 and E-5, the design changes at mud line, the pier being sharply narrowed down and carried up on a tapered or "battered" section buttressed to the outside walls. This left the east and west outside rows of dredging wells with their tops at the level of the bay bottom; and to prevent the infiltration of mud, these wells are capped with concrete slabs poured on the deck of a barge and lowered into place, being fitted where necessary by a diver. Pier E-4, which carries a large top area to accommodate both the anchor span tower and the bearing for the next adjacent span easterly, was carried full width almost to the top.

East Bay Piers Tapered to Tops

When the proper elevation was reached, the anchor bolts for holding the steel spans firmly to the piers were set in place, being stayed with adjustable turnbuckle guy rods. They were then set and checked carefully for position and elevation before concrete was poured around them. In order to give space for subsequent adjustments in erecting steel, these bolts were set in large pipe sleeves.

When pouring the surfaces which carry the main bearing plates for the steel spans, the concrete was struck off very carefully with a trussed steel angle bar riding upon adjustable steel guides. The concrete was then diked and flooded with water for curing, and as soon as hard enough, the bearing surface was ground to uniformity, the permissible variation from a plane surface being one-sixteenth inch.

Creosoted timber fenders were then installed for protection; those on Piers E-4 and E-5 consist of timbers held by galvanized bolts set into the concrete along the east and west walls, and by triangular nose fenders built on driven creosoted piling on the north and south ends. E-3, on the main channel, will be protected by a concrete "mushroom" fender extending around the pier and faced with creosoted timber. In case of a collision this fender is expected to crush in the bow of a ship above water line, thus absorbing the momentum with minimum damage to both ship and pier.

Concrete Mushroom Fender Around Pier

Foundation Conditions

The caissons thus far have passed (in sinking) through layers of clay and clay mixed with fine sand, together with occasional masses of peat. A 10-pound mastodon tooth was dredged up from a depth of approximately 180 feet below sea level in Pier E-5, and the tooth of an extinct species of elk from a corresponding depth in E-4. One hundred and forty feet below the present bottom of the bay had been a prehistoric swamp.

The material encountered showed high resistance to loads when confined, but for the most part cut easily, only a fraction of the expected frictional resistance being encountered. Inasmuch as frictional resistance alone must hold up the caisson while the seal block is being poured in one piece, it was necessary, in the cases of E-4 and E-5, to clean out and seal a portion of the wells at a time, which operation was successfully carried out.

Skin Friction Low

Piers E-4 and E-5 are founded in one of the sandier and more resistant layers of hard clay. Pier E-3 is expected to land in quite sandy material with possibly some gravel, according to preliminary boring investigations, which have checked consistently in the cases of E-4 and E-5.

The top layer of mud on the bottom of the bay is extremely soft; and in the case of Pier E-3 it extended from the bottom at 40 feet below sea level to an elevation 70 feet below sea level, in which the caisson behaved much as though floating free in water. Owing to a slope of the first hard stratum toward the

west, each caisson tilted in that direction upon coming to rest, subsequently being righted during dredging operations.

These piers, together with others on this project on other contracts, are the deepest piers of any kind ever sunk.

General Description of Equipment

East Bay Substructure Equipment

Dredging was done with large 3-drum, electric stiff-leg (tripod) cranes having 100-foot booms. In the cases of Piers E-4 and E-5, each pier was supplied with one crane each on the east and west working platforms. Upon the completion of E-4 and E-5, all four cranes were moved to Pier E-3, which is to be much larger. Principal equipment, in addition to these cranes, consisted of air compressors used for the dual purpose of operating relieving jets and air tools; and large centrifugal pumps to operate water jets, washing hoses, etc. In order to support the heavy weight of the cranes, a 20-inch pipe was driven under the mast of each to a depth of approximately 140 feet below sea level, being subsequently cleaned out and filled with concrete. Extra long wood piles were also driven under the other principal points of support for the cranes.

Concrete Barges Serve Caissons

Concrete was delivered to the piers on barges with the materials weighed out into bins in batches of 3½ cubic yards. These materials were belt-conveyed to mixers mounted in the barges, each having a capacity of one batch. Water was measured into the mixers through meters, being carried to the pier in tanks in the barges. After mixing, the concrete was delivered over belts into a receiving hopper on a separate barge, and from thence taken to the forms or chutes by the cranes in buckets constructed to be dumped from the bottom by hand as needed.

The barges are electrically operated, being supplied with power plugged in at the pier site upon arrival, from a specially laid submarine cable owned by the Pacific Gas and Electric Company, which connects with transformers on the working platforms. The voltage is 440 on a 60-cycle supply. This power also operates the air compressors, cranes, pumps and other equipment.

In placing the bottom seal, buckets were used having trap doors in the bottom so constructed as to open only when the bucket reached solid material. These buckets were fitted with weighted canvas covers to prevent washing of the concrete in transit, and discharged their loads without mixing it with water. Experiments carried out by having buckets lowered and then raised without dumping showed that water damage to the concrete was negligible and slight even when canvas covers were washed off by the rush of water.

Air Driven Vibrators Tamped Concrete

All concrete in the forms was vibrated with heavy air-driven vibrators, no concrete being tamped by hand. Remarkably good results as to absence of rock pockets, etc., were had, although the concrete specified was frequently of a consistency which could not have been handled by hand. It was found that about four vibrators were required for every 75 cubic yards per hour placed, sometimes one vibrator per ten yards, according to conditions.

Working platforms, mooring and protection dolphins, were driven from a combined pile driver and derrick barge using Vulcan No. 2 single-acting steam pile hammers. Pipe piles for derrick supports were driven from the derrick boom, using 10-B-2 double-acting McKiernan-Terry hammers.

Among the interesting features of equipment are the special jets used to clean out seal chambers at 180 to 230 feet below sea level. These are of three types—

straight, unsupported lateral or "angle," and supported or "frame." The two principal problems to be met were driving a jet of water under the cross walls of sufficient force to dislodge the clay there, and of washing off clay adhering to the walls of the dredging wells, especially in the corners. The dredge buckets leave a rounded bottom in each well. This is first squared out by a straight jet throwing its force directly downward. A pipe two hundred feet long being uncontrollable in position from the top, side orifices (reaction jets) were cut in the pipe near the bottom to hold it against the walls. In using the unsupported lateral or angle jet, a horizontal pipe or T-shaped piece was attached to the end of the long vertical pipe. This "T" was open at both ends, the reaction or holding nozzle being larger than the working nozzle in order to force the latter under the walls and cutting edge. The supported or "frame" jet is a square steel frame sliding in the well, carrying a lateral jet of approximately the above description except for the reaction feature, in its center, guided by cables in such a manner that its direction and elevation could be controlled at all times.

Jets Cut Clay From Beneath Cross Walls

A variation of the straight jet has a blade on the end to assist in cleaning walls. All jets were used alternately with the dredge buckets, the latter clearing out material dislodged by the former. So far as practicable, the work was done by straight jets; then by the upsupported angle jets, then with the "frame" jets as a last resort, the time and expense of use increasing with the different types in the order named. Jetting this far below sea level has never been done before; and the mere work of raising and lowering jets, with jointing and unjointing pipes, was a considerable item of time in itself.

Chronology of Piers

	E-2	*E-3*	*E-4*	*E-5*
Cutting edge started				
Steel on hand		June, 1933	August, 1933	August, 1933
Caisson launched		Mar. 2, 1934	Oct. 27, 1933	Aug. 7, 1933
Field work begun	June 26, 1934	Jan. 22, 1934	Aug. 10, 1933	July 22, 1933
Caisson at site		Mar. 20, 1934	Oct. 14, 1933	Aug. 31, 1933
Caisson on bottom		Apr. 18, 1934	Nov. 2, 1933	Sept. 30, 1933
False bottoms out		May 4, 1934	Nov. 15, 1933	Oct. 6, 1933
Caisson sunk to grade		Estimated Aug. 1, 1934	Feb. 1, 1934	Jan. 11, 1934
Cleaned for seal			Mar. 4, 1934	Feb. 8, 1934
Sealed			Mar. 15, 1934	Feb. 10, 1934
Concrete work complete			Apr. 11, 1934	Feb. 24, 1934
Fenders begun			May 23, 1934	May 14, 1934
Fenders complete			Not complete	Not complete

Work on the Army Dock was begun February 15, 1934, but was not carried on consecutively. It should be completed in the early part of July.

Chronology of Contract

Bids received	Mar. 2, 1933
Contract finally approved and filed	May 19, 1933
First work begun in field	July 22, 1933

	E-2	*E-3*	*E-4*	*E-5*
Dates for completion	Sept. 3, 1935	Sept. 3, 1935	July 5, 1935	May 21, 1935
Probable dates of completion	Nov. 1934	Oct. 1934	July 5, 1934	July 5, 1934

It will be noted that this part of the contract is approximately ten months ahead of schedule.

East Bay Substructure—Tideland Piers

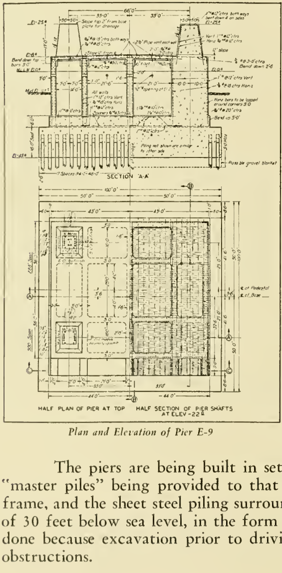
(Contract No. 4-A)

General Description of Work

This section of Bridge Builders' contract comprises the shallow-water, pile foundation piers, beginning with E-6 five hundred feet west of the Oakland terminus of the Key Route railroad, and ending with E-22 seven hundred feet west of the end of the Key Route fill mole, the piers numbering west to east. Piers E-5 to E-9 will carry steel truss spans 509 to 512 feet long; from E-9 to E-22 the trusses will be 291 feet 6 inches to 292 feet 3 inches long.

Piers E-16 to E-22 Built on Piles Within Cofferdams

Of these piers, E-14 to E-22, inclusive, have been completed. E-11 and E-13 are almost complete. E-12 lacks the supporting pylons and incidental work. E-10 has had the seal poured. The foundation piles are being driven in E-9; cofferdam is being driven for E-8; work has been started on E-7, and E-6 has not been commenced.



Plan and Elevation of Pier E-9

Details of Construction

All piers in this section are supported upon wooden foundation piles spaced four feet apart and driven to depths varying from 115 feet to 125 feet below Elevation 0.0, except for certain "battered" or sloped piles which penetrate to approximately 90 feet. The only noticeable deviations from a standard size and type are E-9, which has a very large base, 100 feet square, one of the largest, if not the largest pile bridge foundation ever constructed; and a break in type at E-17. The rising grade from the east, running from E-22 to E-17 was cared for by increasing the heights of the supporting concrete pylons. At E-17 the elevation became so great that it is more economical to create height with steel towers upon relatively low piers. These towers also provide flexibility for the expansion of the future steel spans. The large size of E-9 is due to its function as an anchor span fixing a predetermined point of the bridge against expansion.

Piers Built in Sets of Four

The piers are being built in sets of four, steel cofferdam sheet piling and "master piles" being provided to that amount. Previous to the driving of this frame, and the sheet steel piling surrounding it, the mud was excavated to a depth of 30 feet below sea level, in the form of a large hole with sloping sides; this was done because excavation prior to driving cofferdam is cheaper owing to lack of obstructions.

In driving cofferdams, large "master piles," consisting of I-beams 36 inches in depth by 16 inches in maximum width, and weighing 230 pounds per foot, 72 feet long, were driven to sixty feet below sea level in steel angle frames which space them accurately. Each such pile was faced with a standard sheet pile having interlock grooves on the sides. Into each space between two master piles, three sheet piles were slipped, interlocking with those on the faces of the master piles. The dam was then braced with heavy timber struts running across it from side to side and end to end, near the top, being the only bracing required in this unusual type of construction. The remaining material was then excavated to approximately fifty feet below sea level, tracks set, running north and south on the long sides of the cofferdam, to carry the pile driver (see description under "Equipment") and the wooden foundation piles—approximately 300 in number in most of the piers, 625 in the case of E-9—are driven.

Sheet Pile Cofferdams

The soft mud remaining in the cofferdam was then pumped out, and a gravel blanket varying from two to seven feet in depth was placed to a level grade of approximately 45 feet below sea level in Piers E-9 to E-22, 50 feet in E-6 to E-8. Such pile heads as have not been driven to grade, or have been damaged in driving, were then cut off under water by a diver, and the seal was poured to a depth of sixteen feet.

After setting up for a week, the water was pumped off, the seal cleaned and leveled, and a base block five feet thick was poured. Upon this was built a hollow reinforced concrete shaft up to 8 feet above sea level, which in turn carries the supporting pylons for the bridge. These are hollow to about six feet below the top, being solid blocks from there up. The anchor bolts for the steel span shoes were set in this block.

Concrete Pylons Poured in the Dry

The bridge seats at the top of these pylons are being leveled during pouring, and subsequently ground to bearing, as described in Section 4A. The last operation on the pier is to complete the painting of two coats of protective waterproofing paint, which is begun 5 feet below sea level before the cofferdam is pulled.

Foundation Conditions

The average depth of water at the site of piers is about 14 feet at low tide. The first material encountered is a very soft gumbo mud to a depth of about 30 feet below sea level. At 40 to 50 feet a layer of sand of varying depth was encountered; in some cases jets were required to get piles through this stratum, which, though offering high resistance, is not dependable as a long-time supporter of loads. At 115 to 120 feet, a second layer of sandy clay of high resistance was found, in which the piles reached final penetration.

Average Depth of Water 14 Feet Around East Bay Piers

General Description of Equipment

Dredging, the handling of miscellaneous materials, etc., was done with "whirler derrick," consisting of turntable steam cranes, all-steel construction, mounted upon barges. These cranes, 85 feet long, have a complete circle of swing and very quick action.

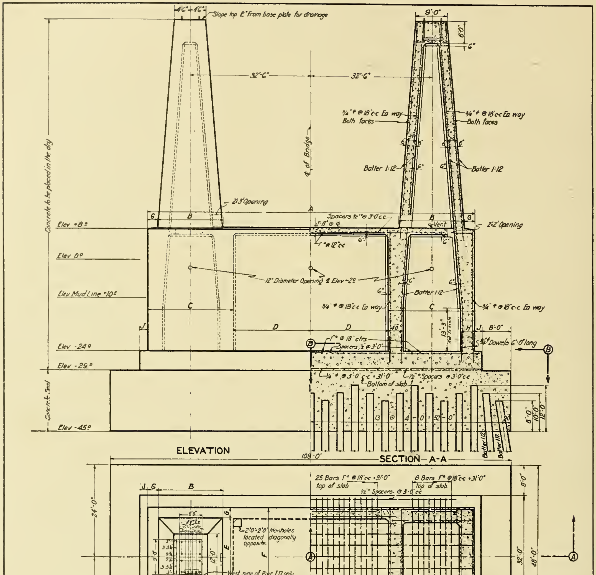
Whirler Derricks Used

Predredging prior to driving guide frames was usually done by specially hired equipment ordinarily engaged in channel dredging, etc.

Cofferdams were driven with steam hammers carried from crane booms and sliding in swinging guides or "leads."

The foundation piles were driven in a very unusual manner; upon the cofferdam piles were mounted longitudinal tracks carrying a heavy steel girder extending from side to side of the pier. Upon this in turn tracks were mounted which carry a steel pile driver on a turntable. The driver could thus run length-

Sheet Pile Cofferdam Details



Plan and Elevation of East Bay Tideland Piers

wise and sidewise of the pier and turn in a complete circle. It was also furnished with sliding leads in which the pile was fastened with a specially designed collar; pile and leads together were lowered in slides until the bottom of the pier was reached, when driving was started. Driving was done with a double-action McKiernan-Terry 10-B-3 steam hammer, submarine type, which has an air hose

connection to the chamber surrounding the pile head. This chamber being kept full of air under pressure, permits the ram of the hammer to strike the head of the pile freely. Steam was carried to the hammer through an armored hose, and the exhaust is carried above water in the same manner. As soon as driving starts, the pile was automatically disengaged from the collar.

Tremie Seal Operations

The same tracks which support the pile driver girder or "gantry" were used in sealing the pier to carry the tremie gantry. This is a wooden truss extending across the pier and traveling lengthwise of it on the rails. In it were mounted three funnel-topped tremie tubes reaching to the bottom of the pier, supplied with concrete from hoppers mounted in the top of the truss. These pipes are controlled by electric hoists which raise and lower them according to the height of the concrete, and impart vertical motion to maintain flow of it; they are also raised out of water to clear the cofferdam struts when encountered in the progress of the gantry. When lowering, the tubes were closed with rubber-gasketed stoppers which are broken loose by the first concrete, the tips being kept in the concrete thereafter except when crossing struts, at which times the plugging was repeated. In operating, the concrete was brought to grade at one end of the pier, and the gantry then traveled consecutively to the other end building up the seal as it went.

Concrete was supplied to the hoppers on top of the gantry by a moving electrically-propelled hopper which was loaded in its periodic returns to one end of the gantry by buckets handled by a whirler derrick, concrete being supplied to this from a hopper barge into which the mixer barges discharge. (See previous section for description of these barges.)

Cofferdams Pumped Out

After the seal was set up, the partial pumping of water produced a stress on the cofferdam sheet piles, causing them to arch in between the master piles and close the interlocks almost watertight. The water was pumped out with large electric pumps, leaving the cofferdam supported by the concrete base bearing against the master piles at the bottom and the wood struts holding them in place at the top. The placing of forms and reinforcing steel then began. Concrete was poured in the forms below the top of the cofferdam by a variation of the traveling gantry idea; a smaller traveling hopper running up and down the pier at the level of the top of the cofferdam (12 feet above sea level) which discharged into small hoppers at the top of jointed pipes (drop chutes) running into the forms.

Concrete was compacted with the vibrators described in the previous section.

Wooden forms were used throughout on these piers; for pouring the supporting pylons, standardized forms were employed, moving from pier to pier.

Pulling Sheet Piles

For pulling cofferdams a heavy barge was used, fitted with a large A-frame and hoists capable of pulling the barge under water if necessary. A small reversed steam hammer was used to vibrate the piling loose while a great strain is maintained on it by the hoist, and where necessary, a multitipped water jet, straddling the master piles, was used to loosen the material around them. The piling was placed on barges and redriven at the next pier needed, as fast as pulled.

For transferring the pile driver and gantry from pier to pier, a large ocean-going wrecking crane, with a lifting power of 250 tons was used, which lifts the driver bodily.

Chronology of Piers

Pier	Start Cofferdam	Excavation Complete	Piles Complete	Sealed	Concrete Complete	Pier Complete	Contract Dates
E 22	9- 5-33	10-16-33	11- 6-33	11-17-33	2-12-34	3- 3-34	3-22-34
21	9-27-33	11- 6-33	11-16-33	11-25-33	2-13-34	3- 9-34	3-22-34
20	9-29-33	11-17-33	12- 1-33	12- 8-33	2-14-34	3- 8-34	3-22-34
19	10- 5-33	12- 2-33	12-14-33	12-21-33	2-23-34	3-12-34	3-22-34
18	1- 4-34	1-23-34	2-13-34	2-22-34	4- 5-34	4-20-34	4-21-34
17	1-24-34	2-15-34	2-24-34	3-10-34	4-24-34	5- 2-34	5-21-34
16	2- 2-34	3- 5-34	3-19-34	3-22-34	5- 4-34	5-10-34	6-20-34
15	2-21-34	3-19-34	4- 2-34	4- 5-34	5-18-34	5-28-34	7-20-34
14	3-24-34	4-19-34	4-24-34	4-27-34	6- 7-34	6-14-34	8-19-34
13	4-18-34	5- 7-34	5-14-34	5-17-34	6-29-34		9-18-34
12	5- 1-34	5-23-34	5-31-34	6- 5-34			10-18-34
11	4- 8-34	4-25-34	5- 5-34	5- 9-34	6-23-34		11-17-34
10	5-24-34	6- 7-34	6-18-34	6-22-34			12-17-34
9	6-11-34	6-17-34					1-16-35
8	6-21-34						2-15-35
7	5-11-34	(Falsework)					3-17-35
6	Not yet						1-15-35

This section of the contract is thus approximately five months ahead of time.

Chronology of Contract

Sections 4 and 4A are one contract; see under previous section for general chronology.

STATUS OF CONTRACT

July 1, 1934

Sections 4 and 4A combined

Contract 4

Pier	Work to Date: Structural Steel	Work to Date: Forms Above C. E.	Work to Date: Concrete Above C. E.	Concrete to Date	Elevation of C. E.
E-3	100%	211	211	27,893	−175
E-4	100%	Off	195	20,461	−171.48
E-5	100%	Off	199	17,414	−169.12

E-4 and E-5 complete except fenders. Creosoted fender piles 100% driven on both piers. E-4 fender 80% complete. E-5 fender 55% complete.

Contract 4-A.

Pier	Guide Frame	Coffer-dam	Exca-vation	Piles	Seals	Concrete To Elev.	Concrete To Date	Progress
E-7	50%	None	None	None	None	None	None	On time
E-8	100%	65%	50%	None	None	None	None	On time
E-9	Out	100%	95%	55%	None	None	None	On time
E-10	Out	100%	100%	100%	100%	−29	2530	On time
E-11	Out	Out	100%	100%	100%	+25	4487	On time
E-12	Out	Out	100%	100%	100%	+19	4030	On time
E-13	Out	Out	100%	100%	100%	+25	4022	On time
E-14	Pier complete					+25.00	4084	(Actual seal
E-15	Pier complete					+25.00	4204	yardage
E-16	Pier complete					+25.00	4111	shown)
E-17	Pier complete					+61.25	5103	
E-18	Pier complete					+53.26	4857	
E-19	Pier complete					+45.25	4730	
E-20	Pier complete					+37.25	4320	
E-21	Pier complete					+29.27	4422	
E-22	Pier complete					+21.25	4216	

Total Value of Contract Bid Items, Sections 4 and 4-A, $4,495,854.00

The value of work done on last monthly estimate, June 20, 1934, was $2,742,186.02, or 61 per cent of the total.

Time elapsed was 48 per cent of the total time allowed, the contract thus being 28 per cent ahead of schedule in proportion of work done.

Contractors Personnel 4 and 4A:

The officers of the Bridge Builders, Inc., are:

Henry J. Kaiser, President.
M. M. Upson, Vice President.
L. S. Corey, Secretary.
K. K. Bechtel, Treasurer.
G. G. Sherwood, Assistant Secretary and Treasurer.

The associated companies comprising the Bridge Builders, Inc., are:

Missouri Valley Bridge & Iron Co., Kansas City.
Raymond Concrete Pile Co., New York City.
The Dravo Contracting Co., Pittsburgh.
Bechtel-Kaiser-Warren Co., San Francisco.
Utah Construction Company, San Francisco.

Yerba Buena Island Anchorages, Piers and Tunnel

(Contract No. 5)

Description of the Work

The work under this contract consists of constructing the Yerba Buena Anchorage of the West Bay Crossing composed of a cable bent and two 163 foot 11 inch concrete anchor blocks with eyebar chains; excavating approximately 330,000 cubic yards of approach cuts and road changes; constructing a reinforced concrete lined tunnel, with reinforced concrete portals, 63 feet 6 inches in width and 540 feet long; constructing a reinforced concrete viaduct with concrete columns, girders and deck 1668 feet in length; constructing two reinforced concrete piers and six reinforced concrete pedestals; moving and reconstructing certain buildings and utilities located on the right of way; placing 4-inch crusher run base with 3-inch bituminous treated road mixed surface on all road changes; constructing necessary sidewalks, curbs and gutters; installing cast iron drain pipe, castings, drain tile, electrical conduits and fittings as shown on the plans.

Yerba Buena Island Anchorage Tunnel and Viaduct Piers

The contract for constructing the Yerba Buena Island section of the San Francisco-Oakland Bay Bridge was finally approved by the Department of Public Works on May 19, 1933, and the Clinton Construction Company, Contractor, began moving in equipment and constructing temporary docks on July 17, 1933.

After landing the material and equipment necessary, the temporary dock on the west side of the island was replaced with a semipermanent structure and a loading dock with belt conveyors was constructed for removing the spoil. A two-yard concrete plant, with a tramway to Elevation 150, was installed between the material dock and the loading dock. The necessary tramways, construction roads, pipe lines, power lines and offices were constructed as needed. On the east side of the island and just south of Army Point a dock was built for the unloading of concrete barges.

Excavation Material Conveyors

Subcontractors

Piombo Bros., Item 1, Excavation
Daniel Contracting Co., Hauling Waste
T. E. Connolly Co., Item 2, Tunnel
T. E. Connolly Co., Item 9, Tunnel Except Viaduct
Western Const. Corp., Item 3, Erection Only
Pacific Coast Steel Co., Item 17, Reinforcing Steel
Victor Lemoge, Item 19, Electrical Work
T. E. Connolly Co., Item 24, Roof Grouting
William Forster & Sons, Item 22, Placing Only
Duncanson, Harrelson Co., Items 26 and 27, Diamond Drilling.

A more detailed report of the contractors' activities follows:

Cable Anchorage

Yerba Buena Cable Anchorage

Excavation for the anchorage proper began on November 6, 1933, the contractor using a 1½-yard gas shovel for this work, and was completed to the top of the footings by January 30, 1934. The excavation for the footings was made by hand with the use of pavement breakers and is now complete to Elevation 93 feet. All excavations for footing were carried to rock.

Photo of status of West Portal of Yerba Buena Island Tunnel, as of July 1, 1934, with anchorage, dirt chute and concrete plant below

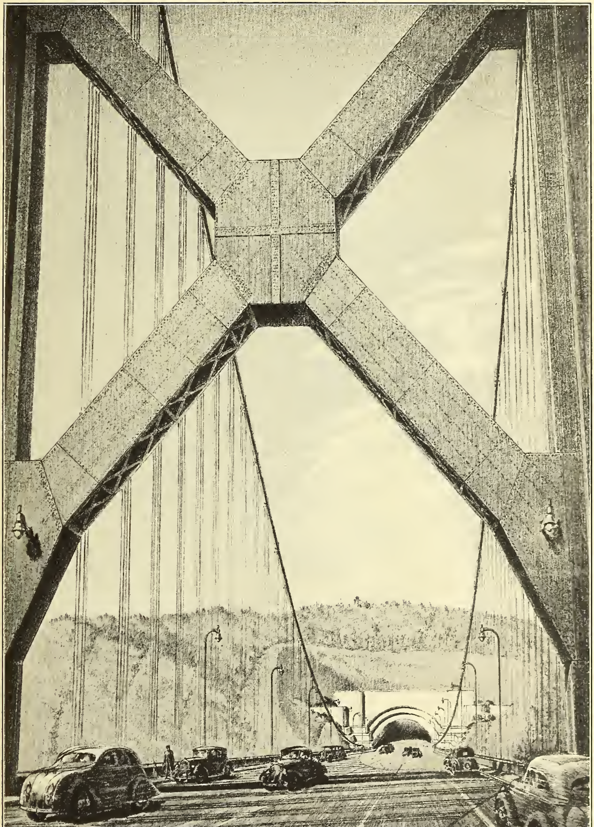
Concrete placing began on April 3, 1934, with the pouring of the footings for the cable bent and has been carried by successive pours to Elevation 103 feet and the bearing surfaces are now ready to be dressed. The footings and walls back of the cable bent are complete to Elevation 89 feet.

Anchor Tunnels

Island Anchorage Tunnels

The contractor began excavating the south pilot shaft on December 27, 1933. After completing the pilot tunnels, the spoil from the enlargement was trapped, hoisted, bunkered and trucked to the disposal chute. All excavation was completed by June 29, 1934.

Forms for the roof were of 2 by 10 sheathing with 10 by 10 post and caps. Concrete pouring began on April 19, 1934, and the roof was completed on May 5, 1934. The plans called for 5-sack concrete, but the contractor elected to use 6-sack with the same w/c ratio; by so doing the increased workability eliminated the use of a concrete gun, the concrete being chuted into place. Concrete was furnished by the island plant.



Architectural conception of West Portal of Tunnel from Tower W-6 on the upper deck

West Approach Cut

Western Tunnel Approach

The western approach to the tunnel was excavated with $1\frac{1}{2}$- and $1\frac{3}{4}$-yard gas shovels and was hauled to the disposal chute in 5-yard trucks. Work began on September 18, 1933, and was completed February 1, 1934. After the original cut was completed it was decided to flatten the slopes and this change was made between February 8, 1934, and March 22, 1934. The material was overcast into the original cut and then rehandled.

Aerial view of Yerba Buena Island. See Pier E-1 on Eastern tip at top of picture and Piers E-2, E-3, E-4 and E-5 in the water

Roof Grouting

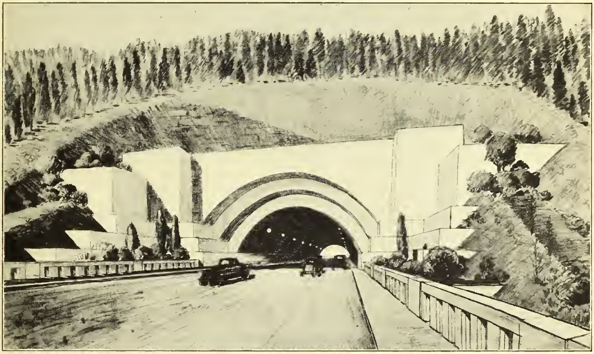
Rock Grouted Over Tunnel

Grouting of the rock over the crown of the tunnel having been specified, the contractor began erecting cables for drill platforms on December 27, 1933, and actually began diamond drilling on January 10, 1934. Completed all work under this item on May 5, 1934. It was found impossible to force any great amount of grout in when the hole was drilled to the full depth, so the contractor elected to stage grout the remaining holes. Pumping of grout ceased when the pressure built up to 260 pounds. A total of 2612 barrels of cement was used which exceeded the original estimtae by 312 barrels.

Main Tunnel

Actual excavation of the vehicular tunnel began on No. 2 drift April 26, 1934. The first round was shot in No. 1 drift May 15, 1934. The present heading of No. 1 is in 310 feet and of No. 2 in 370 feet.

The drifts were 12 by 14 feet in size and an average shot consists of 25 holes, 9 feet in depth with 100 pounds of 40 per cent powder. The amount of ground pulled varies but the average is 7½ feet. Water liners were used in the heading, air being furnished by one 1200-foot and one 550-foot stationary compressor, electrically driven. Mucking was done with a Sullivan drag line mucking machine, the spoil being carried away in 4-yard side dump car hauled with a 10-ton gas dinky to the disposal chute. Fresh air was furnished to the headings by blowers mounted just outside the drifts. This item is approximately 7 per cent complete. Drilling and Mucking in Island Tunnel



Design of West Portal of Yerba Buena Island Tunnel

East Approach Cut

At the eastern portal of the vehicular tunnel work is carried on in the same manner as in the west approach cut. The shovels are now working on Elevation 166 feet. This cut is approximately 90 per cent complete. A portion of this excavated material was used in making backfill and in constructing the fill for the buildings on the right of Station 176. The clay material plugged the disposal chute so permission was obtained to waste this material in washes on the island. Eastern Tunnel Approach

Pier YB-1

Excavation was started on March 31, 1934, using a one-yard clam and was completed to Elevation 133 on April 3, 1934. The contractor began excavating for caisson with a one-yard clam on a stiff-leg skid rig on April 16, 1934. Completed excavation and setting of ribs and liner plates on May 24, 1934. Both footings excavated 5.5 feet into rock.

First concrete was poured in caisson on May 15, 1934, and the last concrete was placed in the caisson on June 18, 1934. This concrete was furnished by the island plant. Island Piers

Forming is now in progress for the remainder of the pier. This piers consists of two 24-foot diameter concrete and steel cylinders, one 84 feet high and one 130 feet high, upon which will rest the concrete pier shafts. Total height of pier will be 202 feet.

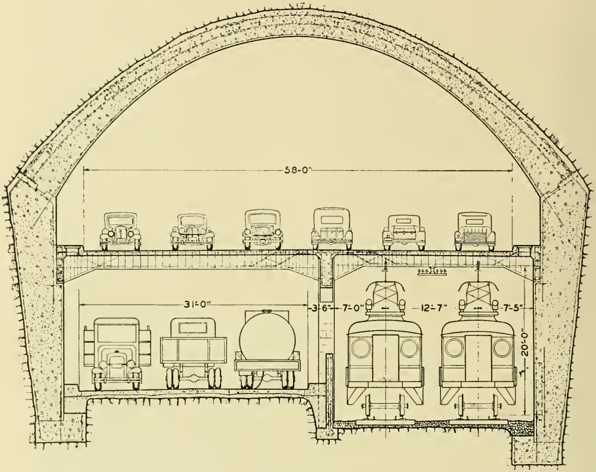
Aerial view of San Francisco in the foreground and Alameda County

with a drawing of the San Francisco-Oakland Bay Bridge superimposed

Pier YB-2

Excavation was started April 26, 1934, with a one-yard clam and completed on June 27, 1934. Both piers have spread footings and are bearing on sand.

South column footing was poured on May 4, 1934; south shaft May 10, 1934, and completed May 28, 1934. No concrete has been poured in the north shaft to date. The spread footings which will carry the pier shafts are octagonal in shape, 43 feet across. Total height 37 feet.



Cross Section Through Tunnel

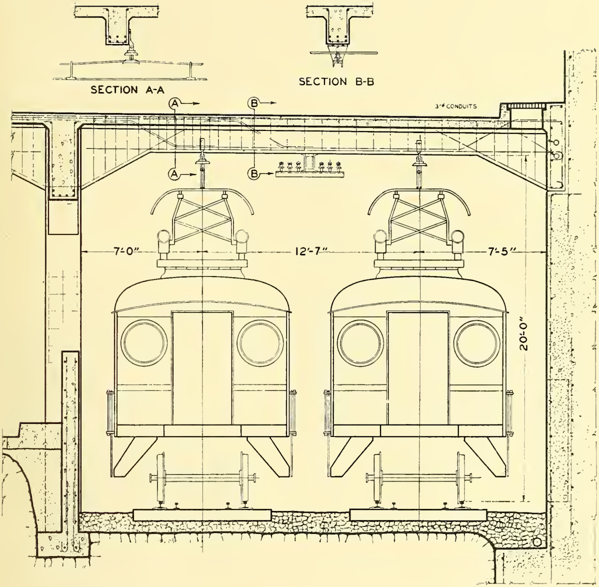
Pier YB-3

Excavation began for the north footing on April 4, 1934, and it was completed on April 13, 1934. Poured first concrete on April 24, 1934, and completed the shaft on May 10, 1934. Concrete was furnished from barges.

It will be necessary to complete YB-2 and the traffic detoured that way before any work can be done on the south shaft. Both piers have spread footings and are bearing on sand. This pier is similar to YB-2, except one footing is 38 feet 6 inches and the other is 43 feet across. Total height 43 feet.

Pier YB-4

Excavation began, using a one-yard clam, on March 13, 1934, and all excavation was completed April 22, 1934. Because of a change in plan elevation of the



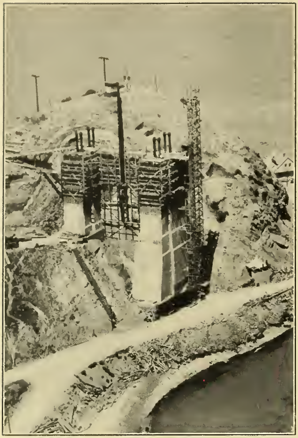
Enlarged Cross Section Showing Tracks

footings and a change in material encountered, the additional depth was excavated. Both piers have bearing on rock.

The footings were poured on April 5, 1934, and April 6, 1934. First shaft pour was made on April 11, 1934, and both shafts were completed on May 10, 1934. Concrete was furnished from barges and trucked to the site. This pier has one spread footing 18 feet square and one 21 x 22 feet, supporting concrete shafts. Total height 65 feet.

Pier E-1

On Pier E-1, the anchor pier at the east end of the 1400-foot cantilever span, excavation began November 17, 1933, and was completed on March 7, 1934. The equipment used consisted of 1½-yard gas shovel and three 5-yard trucks. Spoil was wasted in the fill on the right of Station 176. The pier bears on rock. Anchor Pier



Pier E-1 with eyebars set in place to hold down western end of anchor arm of Cantilever Span

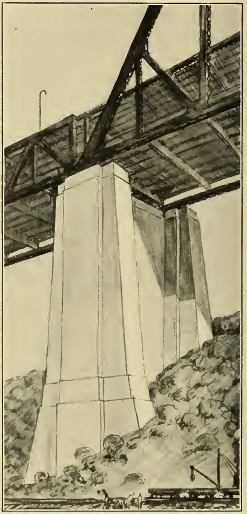
The first concrete was poured on March 13, 1934, and consecutive pours have been made until the concrete is now at Elevation 121 feet. Concrete is furnished by barges, trucked to the pier, hoisted to the upper hopper and placed by buggies. This pier has one spread footing 28 x 68 feet and the other 29 x 78 feet supporting massive concrete shafts. This pier will be 170 feet high and contains 11,100 cubic yards of concrete.

The officers of the Clinton Construction Co. are:

W. B. Brinker President.
Albert Huber, Vice President.
Wm. Joyner, Secretary-Treasurer.

Summary

All items are ahead of the contractor's schedule with the exception of the main tunnel which is approximately three months behind. The project is approximately 37 per cent complete.



Architectural drawing of Pier E-1 as it will appear complete

West Bay Superstructure

(Contract No. 6-6A)

Bids for the construction of the San Francisco-Oakland Bay Bridge were advertised by the State Department of Public Works in January, 1933. The general contract for construction of towers, cables, and suspended spans of the West Bay Crossing from San Francisco to Yerba Buena Island was let to the Columbia Steel Company on May 16, 1933, for the sum of $13,732,471.80. Approximately 21,000 tons of cable steel and accessories, and 65,000 tons of tower and suspended span steel are involved in this contract.

Arrival of First Steel February 6, 1934

Steel was started through the shops for fabrication on September 2, 1933, and was received at the Oakland Storage and Painting Yard on February 6, 1934. First steel was erected on February 26, 1934, at Tower 2, the most westerly support of the suspension spans between San Francisco and Yerba Buena Island. This tower is now practically complete. Erection of Tower 3, 2310 feet distant to the east, will be started about July 15th, and cable spinning operations begun late in the year for the first suspension span unit between the San Francisco shore and the central anchorage pier. The entire contract, as of June 30, 1934, is 5 per cent complete.

Suspension Tower W-2

Tower W-2, the first to be erected, was started on February 26, 1934, as previously noted. It is built up of two main steel sections, or tower legs, one supporting each cable, and is held together and braced by a system of horizontal and diagonal bracing members. The tower leg sections rest on steel base plates, which distribute the loads to the pier pedestals. The tower rises to a height of 453 feet 6⅛ inches where cable saddles are supported. Transverse spacing of tower legs at the base plates is 83 feet 3⅞ inches, and at the top 66 feet, the distance between centerlines of the cables. Each tower leg has major dimensions of 22 feet 1½ inches by 35 feet 4 inches at pier pedestals and is tied to the pier mass by 40 anchor bolts fastened to steel girders embedded deeply in the concrete. The cable saddles mentioned are 46-ton steel castings shaped and grooved to safely distribute the cable loads to the tower legs. The tower, when completed, will contain 5100 tons of silicon and carbon steel, and 111,000 field driven rivets.

Tower W-2 Erected

Tower erection and bolting had progressed to Elevation 453 feet 6⅛ inches by May 21, 1934. On June 12–13, 1934, cable support castings were placed in a temporary position on the top cross strut by the hammerhead cranes. These cranes were then removed by a temporary guyed derrick set on the top strut and erection of inside tower diaphragms and miscellaneous materials begun. Erection of the tower is 97 per cent complete as of June 30th.

Hammerhead Cranes Erect Towers

A unique feature of the erection is the first use of hammerhead cranes, one for each tower leg, in place of the usual creeper type which moves up the outside of the tower. Each hammerhead crane consists of a 108-foot mast, or vertical member, rising through the central well section of the tower leg and supporting at the top a 53-foot horizontal girder. This girder can be revolved through 360 degrees and supports the traveling carriage from which lifting cables and tackles are suspended. Power for operating the lifting and control tackles is supplied by hoisting cables run down through the central well to pier level and then out to gasoline hoisting engines mounted on a steel barge adjacent to the pier. The lower

40 feet of each mast is always encased by and is wedged to the sides of the well section when lifts are to be made. Tower sections are erected in lengths of 50 feet. When erection to any one level is complete, the hammerhead crane is raised 50 feet, blocked in, and the cycle repeated. Materials for erection are brought by barge from the Oakland storage yard to the pier where they are unloaded to the pier base by a stiff-leg derrick. Erection from this point onward is by hammerhead cranes.

Field Rivets

Of the 111,000 field rivets for Tower W-2, the majority are $1\frac{1}{8}$ inches in diameter and average 5 inches in length. They are shot from the heating forges to the riveters by compressed air through flexible metal hoses. Forty-nine thousand rivets have been driven to date and riveting is proceeding at the rate of 8000 per week.

In accordance with specifications, all sections of the tower columns were assembled at the fabricating shop and the splices fitted and drilled while so assembled.

Towers of Cruciform Shape

Each tower column consists of four main wings, grouped in cruciform shape about a central well, and field spliced to one another along their length. Each wing is cellular, the number of compartments varying from two to six, and itself is spliced as noted above, every 50 feet. Splices in north and south sections stagger with those in east and west sections by one-quarter of the section length.

The assembling of sections was so conducted that at least two complete horizontal splices across the column were at all times fitted and bolted, while adjoining sections are being added or removed.

Shop assembly was intended to insure absolute fit in the field, and so worked out when erected. To eliminate any possible "creep" between wings, and to cap off the shaft, shims were provided between shaft and saddle castings, the top surface of which will not be finished until field measurements indicate the necessary thickness.

Steel Cured Before Erection

An important feature intimately related to erection is that of protecting the steel from corrosion. Steel sections were first shipped to the Oakland yard where the steel was allowed to cure for three months to loosen mill scale. All surfaces were then sandblasted to remove scale and rust, after which a coat of red lead paint was immediately applied.

When the paint had time to dry properly, the members were removed to the site and erected. After the members are riveted the rivets are given two coats of spot paint and then the entire structure given three coats of field paint.

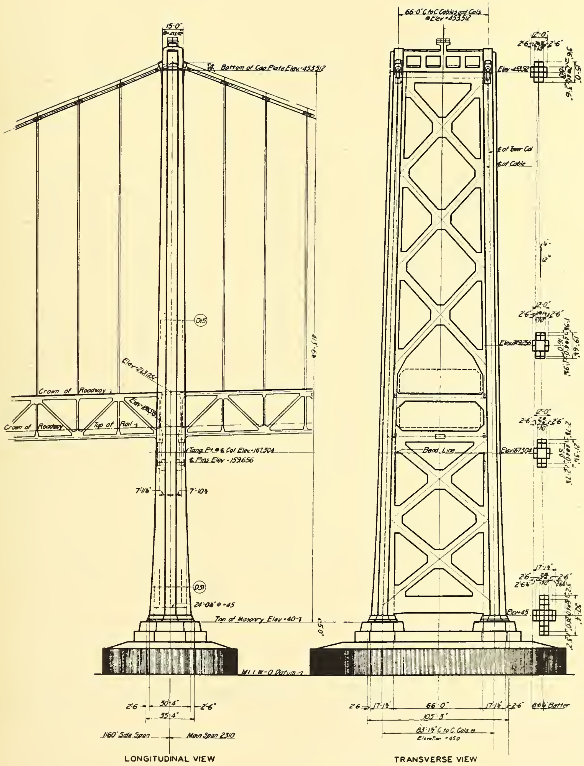
While steel contracts are approximately 5 per cent complete with respect to erection, a total of more than 14 per cent of tower and suspended span steel has been received into the Oakland yard. First cable shipments are now stored in the San Francisco yard. The next year will witness major progress under these contracts.

Columbia Steel Company, contractor, has the following officers:

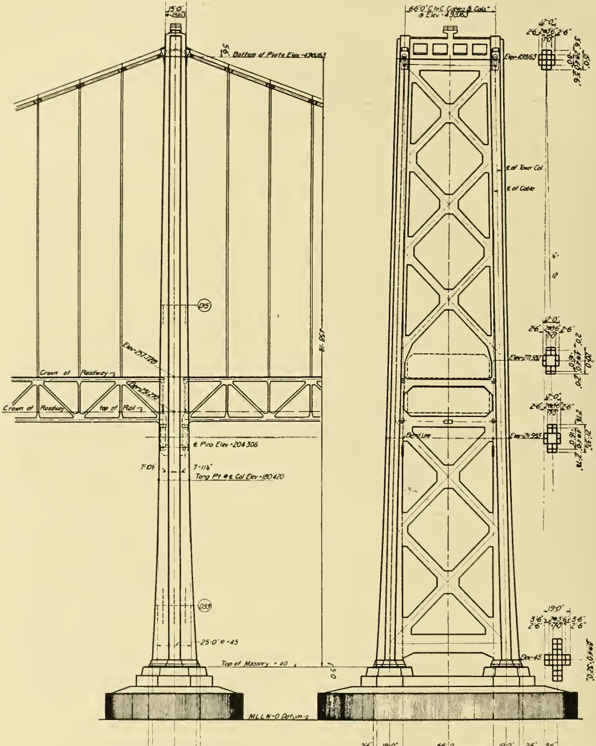
Ambrose N. Diehl, President.
Wm. A. Ross, Vice President and General Manager of Sales.
Kenneth B. Halstead, Vice President.
Harolow F. Wilson, Secretary and Auditor.

The subcontractors:

American Bridge Company.
John Moore & Sons.
Pacific Bridge Painting Co.



Approximate detail of Towers W-2 and W-6



Approximate detail of Towers W-3 and W-5

East Bay Superstructure

(Contract No. 7)

East Bay Towers

There are a total of 18 towers, requiring 13,900,000 pounds of steel, to be constructed under Contract No. 7 in the East Bay.

For Towers YB-2, 3 and 4, requiring 1,500,000 pounds of steel, and being constructed at the American Bridge Company's Ambridge plant, all the material has been rolled and 70 per cent is out of the fabricating shop. **East Bay Steel Towers**

Artist's drawing of 1400-Foot Double Deck Cantilever Span

Nothing has been done to date on Towers E-2 and E-3, which together will require 4,000,000 pounds of steel.

Fifteen per cent of the 800,000 pounds of steel which will be required for Tower E-4 has been rolled preparatory to starting fabrication at the McClintic-Marshall Corporation Steelton plant.

All of the 4,500,000 pounds of steel which will be required for Towers E-5 to E-9, inclusive, has been rolled, and fabrication is 40 per cent complete at the Steelton plant.

For Towers E-10 to E-16, inclusive, involving 3,100,000 pounds of steel, all fabrication has been completed at Steelton and 50 per cent of the material has been shipped to the site.

East Bay Spans

A total of 98,400,000 pounds of steel will be required for the spans in the East Bay. For the Yerba Buena truss spans weighing 8,000,000 pounds, 90 per cent of the material has been rolled and the fabrication is 20 per cent completed at Ambridge.

For the cantilever only the anchorage material shipped to the site, or 5 per cent of the 37,000,000 pounds of steel which will be required, has been fabricated.

East Bay Spans

Seventy-five per cent of the 23,000,000 pounds of steel required for the five 504-foot spans has been rolled. None has been fabricated at the McClintic-Marshall Corporation plant at Pottstown. For the 14 288-foot spans involving 28,400,000 pounds of steel, and being fabricated principally at Chicago, 80 per cent of the material has been rolled, fabrication is 60 per cent complete, and 40 per cent has been shipped to the site. Nothing has been done on the 10 girder spans on the mole.

In all, there will be required 112,300,000 pounds of steel for the East Bay steel contract, and of this 55 per cent of the material has been rolled, 20 per cent has been fabricated, and 10 per cent shipped to the site.

Columbia Steel Company is the contractor.

Substructure—Girder Spans onto the Mole

(Contract No. 8)

General Description of Work

This contract comprises the Oakland approach spans and roadway ramps, which closely parallel the Key Route Mole, the contract beginning at the end of Contract No. 4A, nearly opposite the western end of the Mole. The approach fill in which the structure is partly built, abuts directly upon this Mole, on the norh side.

Bringing Bridge Down to Fill

The contract consists of the following general divisions:

1. Piers E23 to E28, with intermediate Piers E23A to E27A, carrying both decks to the approach fill proper.

2. A concrete lower roadway, carrying truck and interurban traffic, supported upon these piers. (The upper roadway will be supported upon steel girder spans upon the unlettered piers, and is not part of this contract.)

3. Piers E29 to E32, inclusive, carrying the future upper roadway to be supported on steel girders, which girders are not part of this contract.

4. Piers E33 to E39, inclusive.

5. Concrete roadway upper deck supported upon these last piers. This portion of the contract brings the upper roadway down to the approach fill, and is the actual eastern end of the San Francisco-Oakland Bay Bridge proper.

This contract, which is structurally quite complicated, thus for practical purposes consists of the ramp system for distributing the two-deck traffic to the single level of the fill. It also acts as a grade curve system transforming the bridge grade to the level grade of the fill.

The total length of the contract is approximately 1100 feet.

Pier E23 carries, on the west, the most easterly of the 298-foot steel truss spans of the bridge, and on the east the first 82-foot 6-inch steel girder upper deck

span and the first 41-foot 3-inch concrete lower deck girder span. The lettered piers intermediate up to Pier E28 carry only the short concrete girder spans; the spans from E28 carry only the 82-foot 6-inch steel spans up to E33, from which point the remainder of the spans are concrete, 41 feet 3 inches long.

Types of Piers

E23 is a large pier consisting of wood pile foundations, around which an underwater concrete seal four feet thick is poured, sustaining a stepped base block, which in turn carries a hollow shaft up to 27 feet above sea level, containing a transformer floor entered by a steel door. Upon this is supported the lower deck roadways. This shaft is integral with two heavy supporting pylons for the long span on the west, and which pylons stop at 16 feet above sea level, the supporting shoes being between 10 and 11 feet below the deck of the truss. Two pylons rise above the upper deck. Owing to the off-center loading, the pier base is set with its center two feet west of the center of the main shaft.

Hollow Shaft Concrete Pylons

Sub-piers E-23 to E-29 supporting girder spans adjoining the Mole in Oakland Tidelands

E24, E25, E26, E27, E28, of the same general construction as E23, except that they are lighter, smaller, two feet shallower, have a single solid buttressed cross-wall supporting the lower deck span, and the pylons support the upper deck instead of rising above it.

E23A, 24A, 25A, 26A and 27A are each built by sinking three 12-foot steel cylinders, driving therein 12 piles each, sealing under water, then pouring a stepped base upon the seal, which base carries a reinforced round column five feet in diameter. The three columns in turn carry a heavy reinforced cross-cap supporting the lower roadway and interurban deck.

E29 to E32, inclusive, are each built upon two rectangular footings carried by 12 wood pilings per footing. The supporting concrete shafts bearing the upper roadway are tied together by a deep concrete cross-beam.

E33 to E39, inclusive, return to the general type of E24, E25, etc.; full length pile supported footings with buttressed cross-walls.

All concrete girder spans are of the T-beam type, concrete slabs poured with deep girders running from pier to pier. A steel pipe railing is provided for these.

All spans provide for conduits, etc.

Wood piling under this contract is provided by the State, being driven at a unit price per pile.

Details of Construction

Timbered Piles Beneath Concrete

Steel cofferdams are driven around a wood frame cut to proper size, and reaching a depth of approximately 30 feet below sea level.

Wood piles are driven with a conventional skid rig using a Vulcan No. 1 steam pile hammer, single-acting. The rig rests upon wood pile falsework which will also later support the forms for concrete spans. Most of the piles have to be jetted through a shell bed 30 feet below sea level.

Excavation is done with a small clamshell bucket, followed by a mud pump for the softer material. After the softer parts of the bottom are thus removed, the excavation is leveled up with a sand and gravel blanket, and the seal poured thereon encasing the pile heads.

Tremie Seal Operations

The seal is poured through tremie pipes lowered to the bottom closed by plugs. The first batch of concrete poured into the pipe breaks loose the plug, the end of the pipe being then maintained in the concrete and moved consecutively from one end of the cofferdam to the other until the seal is complete. This method excludes the water from the mass of the concrete. After the seal has set for five to ten days, the water is pumped off and the pile heads cut off six inches above the concrete, after which operation the base block is poured. The rest of the pier shaft is then brought up in the usual manner of pouring concrete, using wooden forms.

The setting of the steel cylinders for the intermediate piers is done from a utility pile driver having an extra pair of extra wide slides or leads capable of enclosing the 12-foot cylinders. The cylinders are jetted and dredged to grade, sometimes with the aid of weighting. After reaching full depth with the excavation, further treatment is the same as with those above described.

Concrete Plant

Concrete is mixed in a stationary plant a short distance east of the end of the fill and set thereon. This plant consists of a large compartmented bin to which the different sizes of rock and sand are raised on a conveyor belt, after having been dumped into a concrete lined pit from dump cars brought in on the Key Route tracks. The materials are weighed into the mixer with an accurate beam scale system pre-set to the proper weight for each size of aggregate. Water is measured in a tank which has an overflow outlet which regulates the weight by an adjustable scale.

The mixer is mounted just below the scale system, and in turn discharges into dump trucks which haul the concrete to the designated location. At this point it is run up on a ramp and dumped into two-wheeled buggies which carry it on runways to the proper place for dumping in the forms. For the higher parts of the piers concrete is dumped into a hoist skip and raised.

The concrete is placed with electric vibrators, only a minor amount of hand tamping, etc., being employed.

This general setup has been found to work very dependably and satisfactorily on the whole.

PROGRESS AND STATUS

	Start Work	*Excavation Complete*	*Piles Complete*	*Sealed*	*July 1, 1934 % Pier Complete*
E23	2- 5-34	3-20-34	4-25-34	5- 9-34	80%
E23A	4-13-34	4-25-34	5- 4-34	5-23-34	50%
E24	4- 5-34	5-14-34	5-24-34	6- 5-34	75%
E24A	4-25-34	5-14-34	6-15-34	6-18-34	40%
E25	(Crib for cofferdam partly built—started 6-19-34)				
E25A—No work					

The schedule of the work (revised) calls for the completion of the work in three stages.

	Pier E23	*Pier E33*	*Entire Contract*
Scheduled date	June 25, 1934	October 23, 1934	February 21, 1934
Probable date	July 10, 1934	November 10, 1934	December 10, 1934

While the preliminary stages of the contract are somewhat behind schedule, it appears that the contract as a whole will be completed considerably ahead of time.

PRESENT STATUS OF WORK

Pier	*Cofferdam*	*Excavation*	*Piling*	*Seal*	*Elev. Concrete*	*Per Cent Complete*
E23	Complete being pulled	Complete	Complete	Comp.	36′ above sea level	80%
E23A	Complete	Complete	Complete	Comp.	5.2′ below sea level	50%
E24	Complete	Complete	Complete	Comp.	to 10′ above	75%
E24A	Complete	Complete	Complete	Comp.		40%
E25	Guide Frame built. No other piers started.					
Value of contract bid items						$253,665

The value of work done to last monthly estimate, June 20, 1934, was $55,849.27, or 22 per cent of the whole, with 34 per cent of the time elapsed. This lag in time should be rapidly compensated during the future progress of the work, the most difficult stages having been completed.

Contractor is the Clinton Construction Co. of California, the officers of which are:

W. B. Brinker, President.

Albert Huber, Vice President.

Wm. Joyner, Secretary-Treasurer.

Approach Construction

The progress on the approaches to the San Francisco-Oakland Bay Bridge during its first year of construction work was confined to that section which traverses portions of San Francisco Bay along the northerly side of the Key System mole from its westerly end toward the Oakland shore and northerly along this

shore to the foot of Folger Avenue, Berkeley. Work was begun on this section of the project first due to the advisability of giving these fills as long a time as possible in which to attain the major portion of the settlement expected.

Borings Test Location of Fill

In order that a more stable fill might be constructed, the Berkeley Water Front Co. was awarded a contract under which they made 16 three-inch borings along the center line of the approach adjacent to the Key Mole. Undisturbed samples of the underlying strata to a depth of from 40 to 90 feet were taken on these borings and tests made upon them by the Sacramento testing laboratory to determine the weight per cubic foot, percentage moisture, percentage consolidation under various loadings, coefficient of friction and mechanical analysis of the materials. From this and earlier data taken from observations, obtained by District IV, Division of Highways on various fills placed for highway routes under its jurisdiction along the shores of San Francisco Bay, it was possible to design a fill which would be more stable and cause less difficulty from settlement than fills made previously.

Rock Wall Protects Sand Fill

On December 14, 1933, the American Dredging Co. was awarded the contract for making the dredger sand fill at a cost of $869,063.32. It was hoped that a contract could be awarded at this same time for the construction of a rock wall protection for the sand fill, but the bid totals were so high that it was deemed inadvisable to accept any bid because of the necessity of keeping the cost of the approaches to the bridge within the $6,600,000 set up for them by the State Legislature, and accepted by the Reconstruction Finance Corporation.

New bids were called on a revised typical section and decreased rock quantities, and the contract was awarded on December 29, 1933, to Fredrickson and Watson Construction Co., Fredrickson Bros. and the Basalt Rock Co. at a cost of $274,687.50. The dates for completion of the above contracts are June 14, 1935, and June 27, 1935, respectively, although present progress indicates actual completion dates of February or March, 1935.

The work being done under the dredger fill and rock wall contracts are inseparable in regard to economy and practicability of construction. Economical placing of rock could not be done from barges nor could it be placed upon a semi-liquid foundation such as the bay bottom found in this close vicinity.

Rock and Sand Fill Jointly

In turn a dredger sand fill could not be placed to an elevation of 13 feet above mean lower low water without a restraining barrier to keep it within bounds, and prevent its being washed out by the tides after placing. For these reasons it was imperative that the contractors so arrange their operations that there would be no conflict or delay in the work. It was so arranged, and to date everything has worked out very smoothly.

3500 hp. Dredger

Actual construction was started on January 8, 1934, when the dredge "Harris" started pumping material for the approach fill. It is a 24-inch suction dredge, one of the most powerful in the United States, and has 750 hp. at the cutter, with an overload capacity of 1600 hp. It develops 3000 hp. at the pump and is capable of 3500 hp. The dredge is a very economical plant, having an all electric "Scherbins Control," which gives wide pumping latitude and can be operated at a pressure up to 155 pounds per square inch. With a discharge velocity of 14 feet per second it pumps an average of 11 per cent solids. On June 19th a record output was obtained of 25,400 cubic yards in 23 hours pumping time, or about 1100 cubic

yards per hour. This was accomplished with a 12,000-foot or 2¼-mile length of pipe line without a booster.

The material for the fill is being taken from an area in the Oakland Outer Harbor north of the present channel, and is giving the Port of Oakland an excellent turning basin and channel varying in width from 1200 to 1800 feet. The material taken from this area contains an average of 75 per cent fine sand and makes an ideal fill. The fill is built in three stages or lifts; the bay bottom having been dredged of a portion of the mud under the highway proper before filling is begun. In general, the first operation on the work has been to dredge out about 10 feet of the mud from bay bottom, except at the end of the Key System mole and in places where a good foundation was found on the surface. The best design indicated that it would be desirable to have the dredging carried to a depth greater than 10 feet where old, mud-filled channels crossed the highway but limitation of the amount of money available for use on this work made it impossible to do this.

Sand Fill in Three Lifts

The westerly 2000 feet of the fill was needed, on February 1st, for the use of the bridge contractor building the steel and concrete approach spans to the bridge proper, and so was built up as fast as possible, without danger of slides, and delivered to the above contractor in February, 1934.

Dredging out of the mud and placing it alongside the highway was started at the end of the above section, and has been completed throughout the remainder of the mole and to a point northerly along the bay shore 400 feet north of the Judson Manufacturing Company's property, 846,500 cubic yards of mud or 90 per cent of this contract item, having been dredged to date.

In the process of this work, it was necessary to remove a 38-foot section of the Twenty-second and Thirty-sixth streets lateral sewers, above the flow line, in order to allow passage of the dredge into the portion of the highway between the Oakland outfall sewer and the present mole. These were rebuilt upon completion of the dredging. This work was done by the dredge *Richmond* which is an 18-inch all electric suction dredge.

The first stage of fill was placed to an elevation of +3 mean lower low water. Suspended mud and light clays washed from the sand pumped to the fill and redeposited from the dredging out operation formed mud waves ahead of the toe of the fill, at times, and caused considerable trouble at the outlet to the Oakland outfall sewer, making it necessary to keep the dredge *Richmond* near on standby service to keep the channel open until this section of the fill was complete. Every precaution was also taken to keep the outfall sewer from being moved laterally. This stage of the fill has been placed throughout the mole section to date.

Temporary Bulkhead for Sand

Upon completion of the first stage of the fill a temporary bulkhead, four feet in height, was constructed during the low stages of the tides. This bulkhead served the dual purpose of reducing the amount of core rock necessary in the rock wall facing for the fill and retaining the second stage of the fill which was then placed to an elevation of +7. This second stage in turn served as a roadway for the operation of the rock contractor, and over which 75 hp. caterpillars and 25 to 30-ton capacity Le Tourneau wagons, equipped with eight oversize pneumatic tires, were able to operate a few hours after pumping on this stage had ceased.

Core rock was moved into position beyond the temporary bulkhead to an elevation slightly above +7 by four Le Tourneau wagons, and bulldozed into shape.

Status of West Bay Crossing July 1, 1934

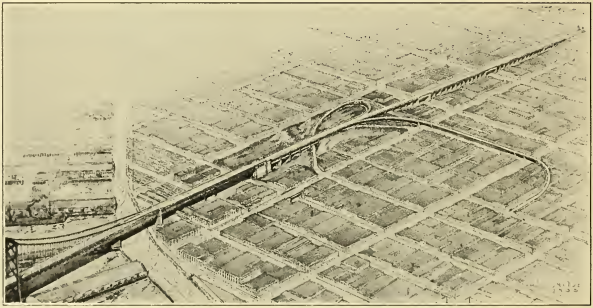
Status of East Bay Crossing July 1, 1934

When this was completed, face rock was placed on the exposed face, and then the remainder of the core rock needed for the wall was placed to the final grade elevation between +13 and +15. This roughly shaped wall was then backed with sand to prevent excess leakage through it during the pumping of the third stage of filling.

The placement of the remainder of the face rock to complete the wall was deferred until the third or final stage of fill had been pumped to grade in order that the rock might be placed by dumping from Le Tourneau wagons rather than by the more expensive method of hand placing by crane or shovel.

Napa Rock in Fill

The rock contractor has furnished rock on a guaranteed maximum specific weight basis of 145 pounds for core rock and 150 pounds for face rock. This rock has been furnished from the Napa quarry of the Basalt Rock Co. and a portion of the core rock from the Richfield Quarry in Richmond. The rock was shipped by barge and unloaded into bunkers on a temporary timber pile dock by means of a 2½-yard floating clamshell derrick.



Drawing of San Francisco automobile approaches

Sand and Rock Fill 40% Complete

The contractor has placed the entire section of wall from the beginning of the fill, at the end of the mole, to the outfall sewer outlet including a short section necessary to maintain a sewage outlet channel. This section contains about 56,700 tons of core rock and 29,200 tons of face rock and represents 40 per cent of the work to be done under this contract. It was completed on May 19, 1934, 26 per cent of the contract time having elapsed. The contractor's equipment has been removed from the job until the dredger fill shall have been completed along the mole section before resuming operations, as no wall will be placed along the outfall sewer.

Placing of the third or final stage of the fill was delayed as long as possible after completion of the second stage; not sufficiently long, however, to conflict with the well-timed and planned schedule of the dredging operations. This stage was placed to an elevation sufficiently above the grade line of +13 feet to allow for the anticipated settlement and consolidation that the fill will take in the years to come.

This portion of the fill was made by placing cross dykes along the fill about 2200 feet apart, which with the dykes along either side of the fill, formed a series of settling basins.

The dredger pipe was set at one cross dyke and a spillway outlet of four 24-inch pipes laid at the next dyke to allow the water from the dredger pipe line to escape after the sand which it carried had been deposited in the basin formed. In several places along the line of the rock wall the concentration of this weight added to the wet sand under it caused the material to slip out and leave a low spot in the fill.

These holes were filled later by bulldozing material into them when it was certain that the sand had stabilized. This final stage has been completed along the entire mole section.

2,408,000 Cubic Yards of Sand Dumped Into Fill

The dredging contractor has pumped 2,408,000 cubic yards of sand from the Oakland Outer Harbor to the approach fill which represents 66 per cent of the contract quantity. The entire contract is 63 per cent complete and only 37 per cent of the contract time elapsed.

As a part of the right of way agreement with the Paraffine Companies in Emeryville, where the highway cuts through their property, it was agreed that a double 9 foot by 9 foot concrete subway would be built to allow passage of their trucks from the plant to the waterfront property and export docks. The contract for this job was let on April 7, 1934, to Healy-Tibbitts Construction Co. for $26,433.50.

To date the cofferdam, excavation, driving of piles and forms for the floor slab have been completed. Pouring of concrete will start within the next week. As regards cost this structure is 38 per cent complete, while 70 per cent of the contract time has elapsed.

In the drafting room plans are now being prepared for the traffic distribution structure in the east bay in the hope that it may be advertised for contract in November, 1934. Plans for the San Francisco approaches are getting well along for advertisement at an early date.

The approaches to the San Francisco-Oakland Bay Bridge are being financed from the State Highway Construction Fund, Primary North, from the appropriation of $6,600,000 made by the State Legislature in 1933 to be expended at the rate of $1,650,000 per year.

Material Tests and Research

Inspection and tests of all materials, including all mill and shop fabrication inspection, qualification of welders, chemical analyses, timber creosoting, etc., are conducted by the Materials and Research Department of the Division of Highways. All foundation investigations and soil analyses and tests have been handled through the same department since construction operations were started.

Cement

Extensive Studies of Cements

Preliminary to starting construction, the Department made an extensive investigation of the characteristics of hydraulic cements tending to a high degree of resistance to the weathering action of sea, alkali, and sulphate waters.

As a result of these studies, combined with studies made by national agencies, it was definitely determined that the compound in cement most susceptible to weathering influences of the nature described was tri-calcium aluminate, and the specifications for the Bay Bridge cement were, therefore, drawn so as to require that the percentage of this particular compound be held to a practicable minimum, the limit in the specifications being fixed at not to exceed 8 per sent. Under these specifications, all cement used in the Bay Bridge concrete contains considerably less than 8 per cent of tri-calcium aluminate and tests of this special cement carried on over an extended period of time have demonstrated its superiority over standard cements. It is highly resistant to sulphate action and the concrete constructed therewith will undoubtedly be much more durable in sea water than concrete constructed with the standard commercial grades of cement. This special cement is designated by the cement companies as "Bay Bridge Cement." It is not a proprietary product in any way and is being manufactured by all three companies furnishing cement for Bay Bridge construction since the inception of the work.

Chemical Analyses

In addition to the usual physical tests to determine compliance with standard specifications for strength, a complete chemical analysis is made of all bins of cement manufactured and set aside for Bay Bridge use. Chemical analysis is also made of all paint and steel furnished for the work.

Concrete Control

The Department is supervising the design of concrete mix and the batching of materials at the plants of the Concrete Products Sales Company in Oakland and on Yerba Buena Island. This company is furnishing concrete for all of the pier construction on Contracts 2 and 4 and for the Tunnel, Anchorage and Approach Trestle construction on Yerba Buena Island. Similar supervision is being given at the plant of the Healy-Tibbitts Construction Company in San Francisco, contractors for the San Francisco Anchorage and Approaches.

Uniform Quality Attained Through Rigid Control

Through rigid control of the coarse and fine aggregates at the source of supply and the subsequent batching through automatic weigh-batching plants, it has been possible to furnish a very uniform grade of high quality concrete for all classes of Bay Bridge construction and for the varied placement methods required by the different types of construction.

Light Weight Aggregate

Light Weight Concrete Sufficiently Strong for Upper Deck

Extensive studies were carried on in connection with the development of a specification for a light weight coarse and fine aggregate with which it will be possible to manufacture concrete of the desired strength, weighing not over 100 pounds per cubic foot, for the Upper Roadway Deck. As a result of these investigations specifications were drawn that formed the basis for a contract awarded early in 1934 to Gravelite, Incorporated, for manufacturing and furnishing 28,000 cubic yards of light weight aggregate.

Gravelite, Incorporated, is now manufacturing and stockpiling specification light weight material at their plant located on the property of the Richmond Pressed Brick Company, Richmond, California, the manufacturing operations, tests and acceptance of the material being under the supervision of the Materials and Research Department in so far as compliance with the specifications is concerned.

Welding and Qualification of Welders

The fabrication of the steel members calls for considerable arc welding, especially in the caisson construction and the roadway floor trusses.

Arc welding is the process of joining steel parts in the molten, or molten and vapor state, by the electric arc without the application of mechanical pressure or blows. The arc weld is a weld in which welding heat is generated by an electric arc formed between the base metal and the electrode, or between two electrodes, with or without the use of hydrogen or equivalent gases.

The electrode is a specially prepared metal wire or rod used as a terminal in an electric circuit to produce an intense heat by means of an arc, and which supplies the molten metal required for joining the parts to be welded.

Arc welding as a substitute for riveting is a comparatively new process. Specifications controlling the nature of the welding rod and the method of operations essential to a first class weld have not been entirely satisfactory. Therefore, as soon as construction operations were started the department drew up special instructions covering the quality of the welding rod and method of procedure.

These specifications have since been made standard for similar operations on all State highway steel construction and are likewise being utilized by the State Division of Architecture.

Miscellaneous

Approximately seventy commercial concerns in the Bay Region are supplying or fabricating materials for the Bay Bridge, either directly or through the construction contractors. It is necessary that the Department maintain close contact with all of these companies to insure that materials and supplies are of the specified quality before shipment.

STATUS OF RIGHT OF WAY DEEDS ON JULY 1, 1934

	Line	Total No. of Deeds	Deeds Executed No.	Cost (Not including title reports, insurance, engineering, contingencies, etc.) Land	Impr., etc.	Total
Bridge	Original Line	60	34	$545,645.00	$176,869.25	$722,514.25
	Stillman St. Change	47	1	65,625.00	99,245.20	164,870.20
	Total	107	35	$611,270.00	$276,114.45	$887,384.45
S. F. Bridge Approaches	5th St. Approach	11	4	$26,100.00	$26,894.00	$52,994.00
	"On" Ramp	8	4	32,000.00	13,990.00	45,990.00
	"Off" Ramp	34	12	33,920.00	45,494.00	79,414.00
	Total	53	20	$92,020.00	$86,378.00	$178,398.00
Ala. Bridge Approaches	Cypress St.	89	27	$65,778.43	$23,121.93	$88,900.36
	38th St.	90	18	26,174.65	21,490.86	47,665.51
	Ashby Ave.	43	10	38,984.40	13,025.00	52,009.40
	Total	222	55	$130,937.48	$57,637.79	$188,575.27
Grand Totals		382	110	$834,227.48	$420,130.24	$1,254,357.72

CONTRACT PAYMENTS AS OF JUNE 30, 1934

No.	*Completed to Date* *Contract*	*Contingency Work Orders*	*Total*	*To Complete*	*Total of Contracts*
2	$6,517,358	$11,448	$6,528,806	$891,819	$7,420,625
3	527,875	3,301	531,176	627,404	1,158,680
4	2,959,577	81,483	3,041,060	1,564,759	4,605,819
5	574,551	158,071	732,622	1,719,468	2,452,090
6	681,937		681,937	13,194,415	13,876,352
7	14,920		14,920	9,089,226	9,104,146
8	60,286	1,699	61,985	202,303	264,288
	$11,336,504	$256,002	$11,592,506	$27,289,394	$38,882,000

Original Contracts		$37,094,979
Provided for Contingencies	$1,787,021	
Other Work Through Contingencies	430,000	
		2,217,021
Estimated Total of Contracts 2 to 8 inclusive		$39,212,000

ESTIMATE OF CONTRACTS TO BE LET AS OF JUNE 30, 1934

Contract No.		
9	Field Painting	$808,500
10	Wrapping Cables	250,000
11	Lighting	330,000
12	Tunnel Lining	60,000
13	Administrative Building	300,000
14	S. F. Demolition	75,000
15	S. F. Section	869,450
16	Opr. Equipment	30,000
17	Superstructure, Harbor Pier 24	50,000
	Total	$2,772,950

SAN FRANCISCO-OAKLAND BAY BRIDGE

CONSOLIDATED STATEMENT OF RECEIPTS AND EXPENDITURES

From September 14, 1932, to June 30, 1934

RECEIPTS		
Bonds sold to R.F.C.		
June 12, 1933 $2,000,000.00		
Sept. 8, " 2,000,000.00		
Nov. 21, " 2,000,000.00		
Jan. 20, 1934 3,000,000.00		
Mar. 19, " 3,000,000.00		
June 5, " 3,000,000.00		$15,000,000.00
Transfer From State Chapter 400		10,803.39
		$15,010,803.39
EXPENDITURES		
Engineering Design	$ 225,195.43	
Triangulation and Surveys	102,245.29	
Launch Operations, including cost of Boats and Radio 'Phones	59,460.09	
Administration including S.F. Office Rent, 'Phone, Clerical and Accounting Staffs, Progress and Traffic Studies	104,492.64	
		491,393.45
Consulting Engrs. and Consulting Archts.		189,563.26
Insurance		413,500.33
Legal		65,428.18
Property - Right of Way S.F. Approach		839,374.42
Rental of Pier 24		27,083.29
Moving Cables - West Bay		91,686.02
Inspection of Steel, Concrete and Materials, All Contracts		107,782.86
Contract 2 - Substructure - West Bay Crossing		5,951,250.04
Contractor's Pay Estimates	5,880,202.99	
Engr. Supervision and Expense	60,184.19	
Diving Operations	10,862.86	
Contract 3 - San Francisco Anchorage		500,478.64
Contractor's Pay Estimates	484,803.17	
Engr. Supervision and Expense	15,675.47	
Contract 4 - Substructure - East Bay Crossing		2,798,072.44
Contractor's Pay Estimates	2,740,412.62	
Engr. Supervision and Expense	44,902.50	
Diving Operations	12,757.32	
Contract 5 - Yerba Buena Island Crossing		699,559.65
Contractor's Pay Estimates	680,694.36	
Engr. Supervision and Expense	18,865.29	
Contract 6 - Superstructure - West Bay Crossing		620,539.14
Contractor's Pay Estimates	615,513.82	
Engr. Supervision and Expense	5,025.32	
Contract 7 - Superstructure - East Bay Crossing		13,534.15
Contractor's Pay Estimates	13,345.95	
Engr. Supervision and Expense	188.20	
Contract 8 - Girder Spans on Mole		69,581.76
Contractor's Pay Estimates	67,333.76	
Engr. Supervision and Expense	2,090.23	
Diving Operations	157.77	
Interest and Discount on Bonds		605,526.49
		$13,484,354.12
Balance with State Treasurer		1,526,449.27
		$15,010,803.39

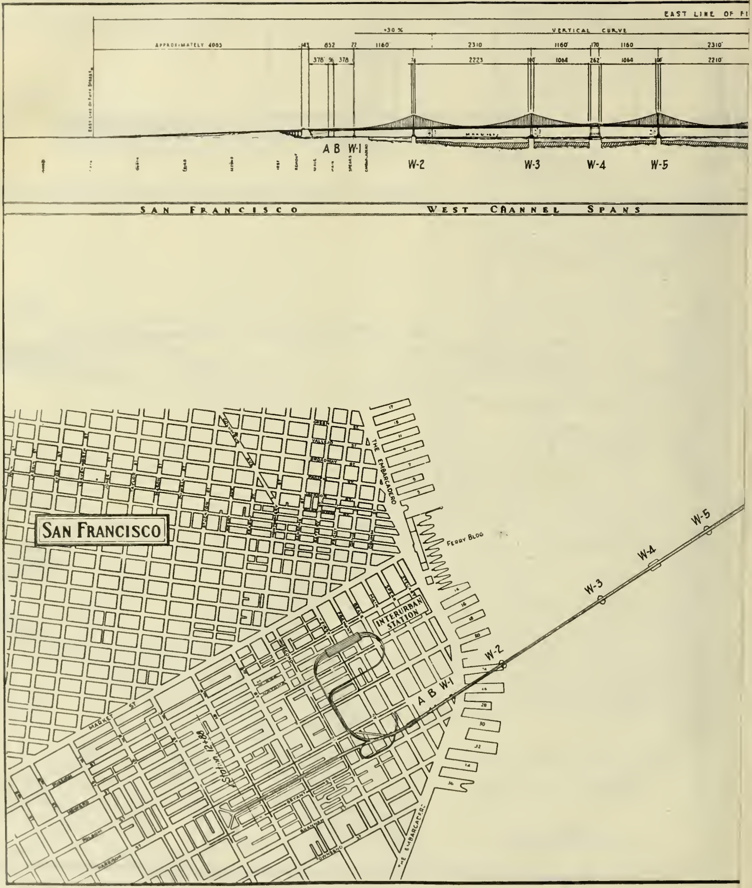
INDEX TO ILLUSTRATIONS

INDEX TO DRAWINGS AND DETAILS

APPENDICES
A to L

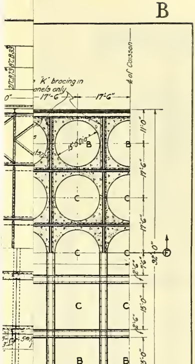
FOLDOUT

A

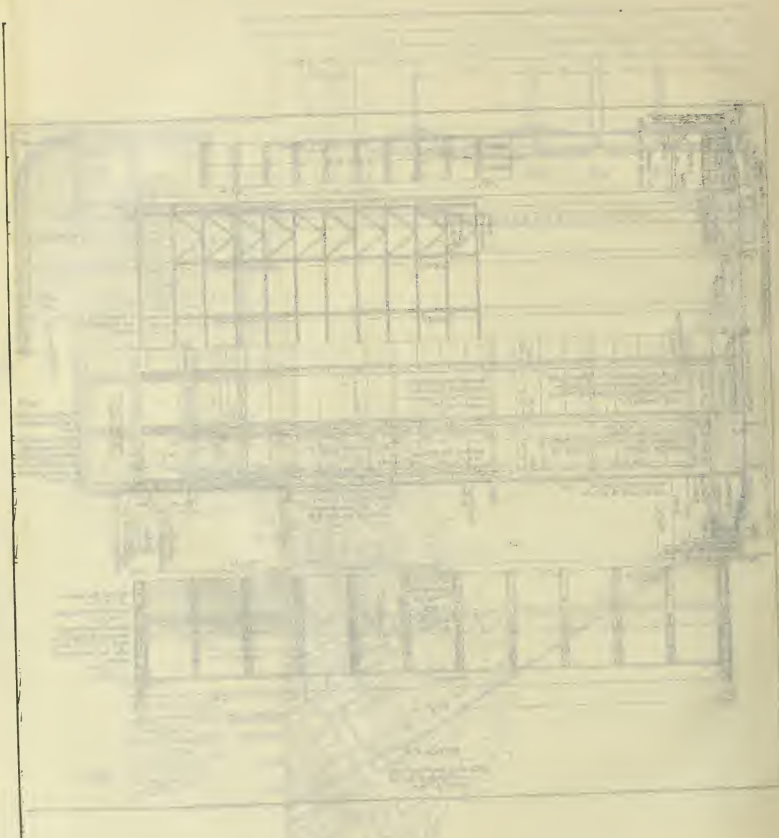


EAST LINE OF F
+30 %
VERTICAL CURVE
APPROXIMATELY 4065
652
1160
2310
1160
170
1160
2310
378' 96 378
2223
1064
262
1064
2210
A B W-1
W-2
W-3
W-4
W-5
SAN FRANCISCO
WEST CHANNEL SPANS
SAN FRANCISCO
THE EMBARCADERO
FERRY BLDG
INTERURBAN STATION
MARKET ST
A B W-1
W-2
W-3
W-4
W-5
Station 12+88
THE EMBARCADERO

FOLDOUT



B
"K" bracing in
17'-6"
17'-6"
℄ of Caisson
15'-0" dia
B
B
C
C
C
C
C
C
B
B
11'-0"
17'-6"
17'-6"
7'-6"
15'-0"
15'-0"
92'-0"
15'-0"
ECTION E-E
Conduits added
Outline of superstructure changed
Date
By
Chk'd
ES
not less than
in corner
Class "A" and
Item No 3.
be chamfered
to be lapped not
TATE OF CALIFORNIA
EPARTMENT OF PUBLIC WORKS
CISCO-OAKLAND BAY BRIDGE
CTURE-WEST BAY CROSSING
PIER NO. 4
RAL PLAN OF CAISSON
SCALE IN FEET
RACT NO. 2 SUP. DRAWING NO. 13A
APRIL 1934



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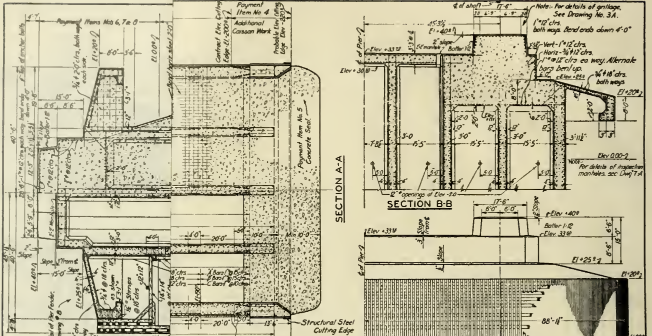
C


SECTION A-A
SECTION B-B
ELEVATION
-NOTES-
Concrete Seal to be Class A.
All other Concrete to be Class B.
All exposed edges of concrete to be chamfered 1"
Reinforcing Steel, when spliced to be lapped not less than 40 diameters.
Reinforcing Steel to be embedded not less than 6" unless otherwise shown
All temporary construction to be removed above Elev -40.0
Note:- For details of grillage, See Drawing No. 3A.
Note:- For details of inspection manholes, see Dwg 7A
Payment Item No 4
Additional Caisson Work
Payment Item No. 5 Concrete Seal.
Payment Items Nos 6, 7 & 8
Payment Items Nos. 10 & 12
Structural Steel Cutting Edge
TAIL OF REINFORCING STEEL IN CAISSON
SCALE IN FEET
1/4 SECTION THRU CU
1/4 SECTION THRU C
BOARD OF CONSULTING ARCHITECTS
BOARD OF CONSULTING ENGINEERS
APPROVED
Director of Public Works
CORRECT
APPROVED
STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
SAN FRANCISCO-OAKLAND BAY BRIDGE
SUBSTRUCTURE-EAST BAY CROSSING
PIER E3
GENERAL PLAN & ELEVATION
SCALE IN FEET
CONTRACT NO. 4 SUP. DRAWING NO. 5A
JULY — 1933

FOLDOUT

D

IDS

SILAS MASON CO.
IDDER

500-5TH AVENUE
NEW YORK CITY, N.Y.

$ 875,000.00

UNIT PRICE		AMOUNT			
21	50	5	773	653	00
25	00		250	000	00
8	00		440	000	00
15	00		321	000	00
12	00		324	000	00
12	00		726	000	00
0	04		152	000	00
0	06		18	000	00
00	00		110	000	00
0	08		36	000	00
			150	000	00
2	20		11	000	00
TOTAL.		$ 8	311	653	00

STATE OF CALIFORNIA

SAN FRANCISCO-OAKLAND BAY BRIDGE

SUBSTRUCTURE WEST BAY CROSSING

[illegible]

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E

STATE OF CALIFORNIA

DEPARTMENT OF PUBLIC WORKS

SAN FRANCISCO-OAKLAND BAY BRIDGE
SAN FRANCISCO ANCHORAGE

CONTRACT NO. 3

Bids Opened
2 00 P.M. March 29, 1933
At City Hall, San Francisco

HEALY TIBBE
CONSTRUCTION C
64 PINE S
SAN FRANCISCO, C
BIDDERS BOND $150.00
CERTIFIED CHECK

ITEM	QUANTITY	UNIT	DESCRIPTION	UNIT PRICE	AMOU
1	50 000	Cubic Yards	Excavation, Unclassified.	2 00	$ 100
2	2,700 000	Pounds	Anchorage Steelwork.	05	135
3	31 000	Cubic Yards	Concrete Anchorage, Mass Concrete Erection Block.	8 80	272
4	34 000	Cubic Yards	Concrete Anchorage, Mass Concrete.	6 00	204
5	3 000	Cubic Yards	Concrete Anchorage, above Lower Deck.	6 00	18
6	300	Cubic Yards	Concrete Viaduct, Footings.	15 00	4
7	5 800	Cubic Yards	Concrete Viaduct above Footings.	9 00	52
8	200	Cubic Yards	Concrete Railings.	30 00	6
9	7,900	Cubic Yards	Concrete Seal, Piers A, B and 1.	5 00	39
10	11 500	Cubic Yards	Concrete above Seal, Piers A, B and 1	11 00	126
11	2,600 000	Pounds	Reinforcing Steel	025	70
12	25 000	Pounds	Miscellaneous Metalwork.	04	1
13			Electrical Conduits and Fittings - Lump Sum.		1
14	20 000	Pounds	Cast Iron Drain Pipe and Fittings	05	1
15	10 000	Pounds	Castings	05	
16	2 000	Barrels	Extra Portland Cement	1 75	3
17			Demolition of Buildings - Lump Sum.		1
TOTALS					$1 036

FOLDOUT

F

	CONTRACTS NOS. 4 & 4A	
INC. ... ALIF.	CONNOLLY – HANRAHAN CO., GEO. G. POLLOCK 461 MARKET ST. SAN FRANCISCO CALIF.	
	UNIT PRICE	AMOUNT
00 00	$ 15 00	$ 109500 00
00 00	15 00	74400 00
4 00	16 10	2317466 20
00 00	11 00	110000 00
00 00	8 00	128000 00
00 00	14 00	122920 00
00 00	04	30000 00
00 00	06	8460 00
00 00		15000 00
00 00	85 00	45900 00
00 00	1 00	11000 00
00 00	06	9900 00
00 00	1 50	3000 00
00 00	50	186000 00
00 00	15	7500 00
00 00	70	15400 00
00 00	15 25	937875 00
00 00	16 12	612560 00
00 00	026	39780 00
00 00	06	11190 00
00 00		10000 00

999670 00	$ 2034450 00	$ 2185565 00	$ 4495854 00	$ 4805851 20

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G

STATE OF CALIFORNI

DEPARTMENT OF PUBLIC WORK

SAN FRANCISCO-OAKLAND BA

YERBA BUENA CROSS

CONTRACT NO. 5.

Bids Opened
2:00 P.M. March 28, 1933
At City Hall, San Francisco

WINSTON BROS. CO.
1470 NORTHWESTERN BNK BLDG
MINNEAPOLIS, MINN.
L. E. DIXON
609 SOUTH GRAND AVE
LOS ANGELES, CALIF
$215,000.00

ITEM	QUANTITIES	UNIT	DESCRIPTION	UNIT PRICE	AMOUNT
1.	330 000	Cubic Yards	Excavation, Unclassified.	.835	$275,550.00
2.	—		Anchorage Tunnels.		123,350.00
3.	3 000 000	Pounds	Anchorage Steelwork.	.078	234,000.00
4.	2 750	Cubic Yards	Concrete Anchorage Foundations.	7.15	19,662.50
5.	8 350	Cubic Yards	Concrete Anchorage Above Founda	12.95	108,132.50
6.	3 000	Cubic Yards	Concrete Viaduct and Wall Footings	10.60	31,800.00
7.	10 000	Cubic Yards	Concrete Viaduct and Wall Above F	20.30	203,000.00
8	300	Cubic Yards	Concrete Railings.	40.91	12,273.00
9.	—		Tunnel Construction.		769,050.00
10.	3 500	Cubic Yards	Concrete Foundations, Piers YB-2 t	7.35	25,725.00
11.	8 500	Cubic Yards	Concrete Above Foundations. Piers Y	10.07	85,595.00
12.	250	Cubic Yards	Concrete Sidewalks, Curbs and Gutt	20.00	5,000.00
13.	850	Cubic Yards	Crusher Run Base	4.52	3,842.00
14	650	Cubic Yards	Crushed Stone Surfacing.	4.60	2,990.00
15.	50	Barrels	Fuel Oil	2.52	126.00
16	50	Tons	Cut-back Asphalt.	35.00	1,750.00
17.	4 400 000	Pounds	Reinforcing Steel	.037	162,800.00
18.	10 000	Pounds	Miscellaneous Metalwork	.13	1,300.00
19	—		Electrical Conduits and Fittings.		10,120.00
20.	1 500	Cubic Yards	Concrete Pavement, Lower Deck.	9.24	13,860.00
21.	51 000	Pounds	Cast Iron Drain Pipe and Fittings	.06	3,060.00
22.	13 000	Pounds	Castings.	.084	1,092.00
23	—		Drain Tile 4" to 12".		1,460.00
24	2 300	Barrels	Portland Cement Roof Grouting.	17.00	39,100.00
25.	23 000	Lineal Feet	Pipe Piles in Place	4.66	107,180.00
26	200	Lineal Feet	Jet Drilling	10.00	2,000.00
27	100	Lineal Feet	Diamond Drilling.	20.00	2,000.00
28	2 000	Barrels	Extra Portland Cement.	2.07	4,140.00
TOTALS					$2,249,958.00

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			PRO'L C'-CONT NO 6-6A	
			COLUMBIA STEEL CO 235 MONTGOMERY ST SAN FRANCISCO $1,660,000 00	
			UNIT PRICE	AMOUNT
			0764	$2,826,800 00
			.0729	729,000 00
			.1112	133,440 00
			0845	59,150 00
			0652	33,252 00
			.1044	58,464 00
			.0630	3,024,000 00
			0597	1,731,300 00
			1023	30,690 00
			0573	34,380 00
			.3270	16,350 00
			15.75	182,700 00
			15.75	99,225 00
			2170	176,855 00
			2170	135,625 00
			.0378	83,160 00
			18.40	40,480 00
			2 10	69,300 00
			.1002	3,747,480.00
			.1196	198,536 00
			1.28	289,280 00
			.2680	10,210 80
			.1028	15,420 00
			.0725	2,392 50
	.25	10,250 00	.1215	4,981 50
TOTALS		$4,812,116.00		$13,732,471.80

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Bids Opened
2:00 PM March 8, 1933

Extensions Checked by........ .....

Checked Against Proposals by.............

TABULATION OF BIDS

	Columbia Steel Co.	McClintic Marshall Co.
BIDDER / ADDRESS	235 Montgomery St., San Francisco	20th & Illinois St., San Francisco
BIDDERS' BOND / CERTFIED CHECK	$900,000.00	$1,100,000.00

ITEM	QUANTITY	UNIT		Columbia Steel Co. UNIT PRICE	Columbia Steel Co. AMOUNT	McClintic Marshall Co. UNIT PRICE	McClintic Marshall Co. AMOUNT
1.	6,800,000	Pounds	Nickel	.0915	$ 622,200.00	.0936	$ 636,480.00
2.	49,000,000	Pounds	Silicon	.0675	3,307,500.00	.0683	3,346,700.00
3.	40,400,000	Pounds	Carbor	.0635	·2,565,400.00	.0639	2,581,560.00
4.	8,500,000	Pounds	Heat T	.0730	620,500.00	.0763	648,550.00
5	7,050,000	Pounds	Silicon	.0790	556,950.00	.0781	550,605.00
6.	4,900,000	Pounds	Carbo	.0715	350,350.00	.0719	352,310.00
7.	50,000	Pounds	Mangc	.0640	3,200.00	.0620	3,100.00
8	25,000	Pounds	Phospl	.3240	8,100.00	.4030	10,075.00
9	12,000	Cubic Yards	Concr	15.75	189,000.00	18.00	216,000.00
10.	6,550	Cubic Yards	Concr	16.75	109,712.50	19.00	124,450.00
11.	825,000	Lineal Feet	Reinfo	.2170	179,025.00	.2150	177,375.00
12	653,000	Lineal Feet	Reinfo	.2170	141,701.00	.2150	140,395.00
13.	2,116,000	Pounds	Reinfo	.0380	80,408.00	.0425	89,930.00
14.	30,500	Barrels	Portla	2.10	64,050.00	2.10	64,050.00
TOTALS					$ 8,798,096.50		$ 8,941,580.00

FOLDOUT

J

BRIDGE BUILDERS, INC.
OUTER HARBOR.
OAKLAND, CALIF.
$40,000

UNIT PRICE	AMOUNT
41 00	23780 00
46 00	19320 00
2 50	6000 00
40 00	17600 00
40 00	34400 00
40 00	42000 00
31 00	173600 00
30 00	3900 00
.04	32000 00
.30	1800 00
.12	600 00
——	1000 00
2 00	2000 00

·TOTALS·				
·TOTALS·		$ 346010 00		$ 358000 00

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K

MATERIALS FURN D TO #4-6 American Dredging Co.
C.M.P and CTOR OF PUBLIC WORKS Dec. 14, 1933
nber 15, 1933.

CONTRACT No. 64TC6

DISTRICT IN Alameda COUNTY:

			American Dredging Company San Francisco			
			$105,000			
1	Rem + Reco.	187.50	18,750			
2	Rem + Reco	88.80	4,440			
3	Dredging	0.0698	66,030 80			
4	Dredger S	0.1998	724,775			
5	Structure	1.81	14,461 90			
6	Cl "A" P.C.C	47.40	33,605 20			
7	Bar Rein.	0.055	2,618			
8	Furnished Douglas F.	0.26	665 60			
9	Driving	8.50	714			
10	8 Vit Sew	2.20	946			
11	12" "	2.52	2459 52			
12	24" "	5.35	749			
13	30" "	10.70	5,564			
14	18" C.M	1.50	534			
15	24" "	1.55	567 30			
16	36" "	2.30	437			
17	Cut Openings	24.00	96			
18	Finishing R	10.00	2150			
NOTE	Suppleme. Not included					
19	Dredger Property at P	0.225	31,500			
			$869,063 32			

L

		26433	50			43517	25		

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Day Bridge	
11.43	7.37
4.06	
5.00	